Review of Water Allocation Planning in South Australia and the impact on potato production

Robin Anne Davis
Potatoes South Australia Incorporated

Project Number: PT13012

PT13012

This report is published by Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the potato industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of Potatoes South Australia Incorporated.

ISBN 0 7341 3313 8

Published and distributed by:
Horticulture Australia Ltd
Level 7
179 Elizabeth Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399

HAL
Horticulture Australia

Review of Water Allocation Planning in South Australia and the impact on potato production

Project Number: PT13012 (20 March 2014)

Robin Anne Davis et al

Potatoes South Australia Incorporated

HAL Project Number PT13012
20 March 2014

Robin Anne Davis
Potatoes South Australia Inc ABN 45 568 994361
GPO Box 1664
ADELAIDE SA 5001
T:(08) 8425 4531
M: 0427 084 319
info@potatoessa.com.au
www.potatoessa.com.au

Russell Martin, Australian Groundwater Technologies (AGT) Pty Ltd
Jim Kelly, Arris Pty Ltd

The purpose of this report concerns the Water Allocation Plans in the Mallee and Lower Limestone Coast Prescribed Wells Areas of South Australia. Reviews of the equitability of the water allocation process have been conducted to determine any scientific justification for the reduction in water allocations in these areas which coincide with the adoption of the revised Mallee Water Allocation Plan in 2012 and the Lower Limestone Coast on November 2013. A study of Irrigation practices and efficiencies in the Mallee Prescribed Wells Area has also been conducted.

The research contained in this report was funded by Horticulture Australia Ltd using voluntary contributions from the South Australian Potato Industry and matched funds from the Australian Government

TABLE OF CONTENTS

Media Summary

Potatoes are Australia's largest horticultural crop and contribute $0.5 billion per year to national GDP.

South Australia produces 385,000 tonnes of potatoes annually with a farm gate value of $206million. It is the nation's largest producer and 75 per cent of the national fresh washed market is grown in the Mallee region, accounting for 41 per cent of the state's production. The Lower Limestone Coast (LLC) region produces 45 per cent of the state's potato crop with a large proportion being processed by McCain Foods in Penola and in Ballarat, Victoria. These two regions produce 86 per cent of the state's potatoes.

This project concerns the reviews of the Water Allocation Plans (WAPs) in the Mallee and LLC regions of South Australia. The change from area-based water allocation (haIEs) which authorised a maximum area of crop to a volume-based licence (volumetric conversion) has resulted in reductions in allocation of up to 50 per cent in some zones in the Mallee and inequities (particularly in the forestry sector) in the LLC. These reductions in water allocation will have significant effects on potato production ($37million annually in the Mallee) including non-viability of current businesses and loss of potential expansion. Other horticultural crops will also be affected.

The unique scientific data used to determine the WAPs has been researched and its interpretation and application reviewed for its completeness. The inclusion of auxiliary water use is of significance as this is additional water required to grow the crop to affect the localised micro-climate including frost mitigation, soil and land management, post-harvest cover crops and potato storage.

This is the first time that the rationale behind the WAPs has been reviewed. This research has tested the WAPsand found the following:

Lower Limestone Coast WAP

- There is sufficient water available across the region to support existing use; and
- Due to the inconsistencies and inequities identified, particularly concerning forestry, its non-allocation and the lack of inclusion concerning the specifics of potato production, a complete review of the WAP is recommended.

Mallee WAP

- The reduction in allocations is extreme, sudden and un-justified by the current or likely long term resource condition (salinity or water pressure levels); and
- A review of the allocation assignments with a view to a more equitable distribution across the management and border sharing areas is recommended.

Mallee Irrigation Practices

Irrigation management practices in the Mallee have also been researched to determine levels of efficiency improvement over the past decade. Changes that have occurred in the past 5-10 years to improve water use efficiency include:

- The introduction of variable rate irrigation (VRI) on pivot irrigators;
- Clay topping and other soil treatments to impact soil moisture retention;
- More rapid maturing cultivars; and

- More attention given to reducing pre-plant and in-ground storage water use.

Crop rotation cycles of 5-7 years were identified as an impediment to new system development.

This three-pronged project provides the basis for ongoing discussions between the potato industry, other irrigators, service providers and policy makers.

Technical Summary

This project comprises three distinct reports:

1. Mallee PWA Water Allocation Review
2. Review of the Lower Limestone Coast (LLC) Water Allocation Plan Allocation Criterion
3. Report on Survey of Mallee Potato Growers on Changes in Soil and Crop Management Practices since 2004

Irrigators in the South Australian potato industry with extensive holdings within the Lower Limestone Coast Prescribed Wells Area and the Mallee Prescribed Wells Area have reviewed the adopted Water Allocation Plans (WAPs) and consider that equity of access to water has not been achieved across all users and that reductions in water allocation are unjustified.

Potatoes South Australia Inc engaged Australian Groundwater Technologies Pty Ltd (AGT) to conduct a review of the water allocations assigned to Border Zones 9A north, 10A, 11A and Management Area Parilla Red as outlined in the Mallee Prescribed Wells Area WAP and also to conduct a review of water allocation criteria within the Lower Limestone Coast Prescribed Wells Area.

Simultaneously, Arris Pty Ltd was commissioned to survey the soil and crop management practices of Mallee potato producers over the past ten years.

1. Mallee PWA Water Allocation Review

Potato producers in Zone 10A and Parilla Red have had water allocations reduced by up to 40% while potato producers in Zone 11A have had water allocations reduced by up to 50% from previous years. The revised water allocation has resulted in limited crop development in 2013'14 and subsequent years and does not provide sufficient flexibility for climatic variations.

Methodology

Independent hydrogeologists, AGT Pty Ltd,will:

- Review all available information as detailed in its Document Review (attached) to confirm the basis for the reduction in allocation in Zones 10A, 11A and Parilla Red and provide comment on the current resource condition and numerical modelling used to justify the reduction;
- Identify any alternative options (ie distribution of irrigators in the area) to minimise the impact on the groundwater resource and determine if a stepped reduction over time could be achieved;
- Review appropriate documentation and liaise with the State Government Department of Environment, Water and Natural Resources (DEWNR) to assist in reviewing the Permissible Annual Volume for the area and the reasoning for the non-uniform reduction in allocation;
- Review the available information to determine if the reduction in allocation is warranted due to increased stresses on the resource.; and
- Liaisewith stakeholders at all steps in project development for feedback on proper issue address.

Key Issues

- The reduction in allocations is extreme, sudden and un-justified by the current or likely long-term resource condition (salinity or water pressure levels);

- The methodology employed in this conversion and in the determination of WAP individual water allocation may be in question due to an incomplete use of the science, its uniqueness to this plan and a lack of understanding of potato crop requirements in terms of auxiliary water;
- Arbitrary shifting of volumes across management zones;
- The adopted Plan ignores evidence of all previous resource condition reports; and
- Significant economic loss will accrue as a result of allocation shortfalls and reductions.

Key Recommendations

- Conduct new additional groundwater modelling incorporating metered extraction and monitoring information to confirm the status of the groundwater;
- Provide a water allocation for auxiliary requirements to all irrigators;
- Adopt a phased in approach over five years during which temporary auxiliary allocations are made available to all irrigators enabling irrigators to make necessary adjustments to water management practices;
- Review the need for a carry-over scheme which would account for variations in climaticconditions or crop rotation periods.

2. Review of the Lower Limestone Coast (LLC) Water Allocation Plan Allocation Criterion

During the conversion from irrigation equivalents to a volumetric allocation a high proportionof irrigators have received a lower entitlement than their previous historical use. Inmanagement areas that are designated as over allocated some of these users are facingfurther cuts making it impossible to grow the same sized crop and therefore making their businesses financially unviable.

Methodology

Independent hydrogeologists, AGT Pty Ltd, will:

- Review the allocations afforded to the Forestry industry and other LLC users to determine if the intent of the allocation guiding principles, including prior use, have been equitably applied across all users;
- Review the method for calculating water allocations for Forestry including plantation forest thresholds, the theory regarding extraction and inception of forestry plantations and the state-wide policy framework used to manage the water resource impacts of plantation forests;
- Review studies of salt accessions under different irrigation types in order to provide insight into return irrigation flows which may not have been accounted for in setting the Permissible Annual Volumes (PAVs) for some of the areas;
- Liaise with stakeholders at all steps in project development for feedback on proper issue address

Key Issues

- Conversion/ calculation of the new allocations from Irrigation Equivalents fails to consider industry best practice;
- Forestry impacts are significantly underestimated;
- Farm forestry should be required to purchase an allocation;
- Forestry should be cut ahead of any irrigation activity;
- Values used to determine forestry allocation are inconsistent with policy;

- There is sufficient water available across the region to support existing use without having to resort to reductions in allocations; and
- Significant economic loss will accrue as a result of allocation shortfalls and reductions.

Key Recommendations

- Conduct a complete review of the WAP due to the inconsistencies and inequities identified, particularly concerning the non-allocation to the forestry sector (20 ha) and the specifics of potato production;
- Access additional data used in the determination of the WAP, particularly concerning the base allocation derivation of 4.2Ml/ha for potato producers;
- Farm forestry to buy allocations to provide proper accounting across all water users and to prevent future impacts and cuts to irrigation use; and
- A physical reduction in forestry allocation matched to annual felling should occur prior to any cuts occurring for other users.

3. Report on Survey of Mallee Potato Growers on Changes in Soil and Crop Management Practices since 2004

The survey attempts to capture any ideas which producers in the region may have on future R&D opportunities for improved irrigation practices, water conservation and improved water use efficiency. It was used to achieve an understanding of how the industry has changed in the last decade years in the areas of:

- Land management
- Crop management
- Water use and management
- Improved farming practices
- Water conservation measures

Methodology

- A desktop literature review and interviews with Mallee irrigators were conducted to determine current irrigation practices and the incorporation of new technologies.

Key Issues

- The current practice of using crop rotation cycles at 5-7 years is an impediment to new systemdevelopment;
- Any changes to production systems that might impact on market quality and appearance needto be carefully considered;
- There are few changes that have occurred in the past 5-10 years to improve water use efficiency. Themost significant changes are the introduction of variable rate irrigation (VRI) on pivot irrigators, clay topping and other soil treatments to impact soil moisture retention and the use of more rapidly maturing cultivars; and
- Whole of farm changes are probably not going to be possible as forsome as seasonal and site situation best practice is already in use.

Key Recommendations

- Reduce pre-planting and in-ground storage water use
- Conduct research into short term (2-4years) continuouscropping systems which would allow for the implementation of new financially viable production systems
- Provide tools for better mapping decisions for use with VRI irrigation

Acknowledgements

These reports, compiled as a Review of Water Allocation Planning in South Australia and the impact on potato production were funded by HAL using voluntary contributions from the South Australian Potato Industry (Potatoes South Australia Inc) and matched funding from the Australian Government.

Mallee PWA Water Allocation Review

Prepared for Potatoes South Australia Incorporated

AGT Report no: 1316-13-PANa
20/12/2013

Australian Groundwater Technologies

"making water work"

Document Control

Document Title

Mallee PWA Water Allocation Review

Report no

1316-13-PANa

Prepared for

Potatoes South Australia Incorporated

Author	**Date**
D. Haworth	12/12/2013
Reviewed by	**Date**
R. Martin	13/12/2013
Approved by	**Date**
R. Martin	16/12/2013

Revision history

Revision No.	Date Issued	Reason/Comments
1	16/12/2013	Draft for client review
2	20/12/2013	Final

Distribution

Copy No.	Location
1	Potatoes South Australia Inc
2	Potatoes South Australia Inc, Minister Ian Hunter

Note: This is a controlled document within the document control system.
If revised, it must be marked SUPERSEDED and returned to the AGT QA Representative

Statement of Limitations

The services performed by AGT have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. This report is solely for the use of Potatoes South Australia Incorporated and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided or conditions encountered at the site during the investigation. AGT has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. AGT assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to AGT was false.

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
Unit 5, 1 London Road, MILE END SOUTH SA 5031
PH: (08) 8352 4262
Fax: (08) 8354 3076
www.agwt.com.au

Executive Summary

Potatoes South Australia Inc. engaged Australian Groundwater Technologies Pty Ltd (AGT) to carry out a review of the water allocations assigned to Border Zones 9A north, 10A, 11A and Management Area Parilla Red as outlined in the Mallee Prescribed Wells Area Water Allocation Plan.

Potato producers in Zone 10A and Parilla Red have had water allocations reduced by up to 40% while potato producers in Zone 11A have had water allocations reduced by up to 50% from previous years. The revised water allocation has resulted in limited crop development in 2013/2014 and subsequent years and does not provide sufficient flexibility for climatic variations.

The reduction in water allocation coincides with the adoption of the revised Mallee Water Allocation Plan in 2012. AGT was commissioned to carry out a review of the equitability of the water allocation process and any scientific justification, i.e. resource stress, for the reduction in water allocations in the area.

Key Findings

The review has identified the following:

- Monitoring and groundwater numerical modelling has concluded that the Murray Group Limestone Aquifer groundwater resource is robust and sustainable under current levels of extraction. Current extraction at annual allowable volume rates of 61,300 ML each year would only lead to a depletion of 15% of the total resource volume of water in storage after 300 years. Additional depletion of the aquifer storage (>15%) would result in a lowering of groundwater levels, however the system would reach a new equilibrium after a period of time. Given the robust nature of the system, additional water allocations above that of the WAP could be made available to irrigators.
- The Border Committee realigned the permissible annual volumes across arbitrary boundaries which were developed as part of the Border Groundwater Agreement in 1985. A portion of the permissible annual volume allocated in Zones 11A and 9A north were reallocated in Zone 10A to allow for the volumetric conversion process (from area based to volumetric water allocations) and to assist with additional irrigation development in the zone.
- Despite the alignment, the aggregated permissible annual volume remained the same which further confirms the robust nature of the aquifer system. In addition, groundwater use in the Parilla Red management area was increased from 3,900 ML to 7,000 ML as historical groundwater use was in excess of 7,000 ML per annum which did not significantly stress the groundwater resource in the area.
- The realignment in the border zone will allow for Priority 1 (developed during the assessment period), Priority 2 (developed post assessment period) and Priority 3 (undeveloped) allocations to be assigned in Zone 10A and possibly allow for additional temporary auxiliary allocations while Zones 11A and 9A north will likely only receive Priority 1 allocations and no temporary auxiliary allocations.
- Zones 11A and 9A north will not be receiving equitable shares of the resource under the current WAP. The permissible annual volume in Zone 10A was increased from 9,000 ML to 14,000 ML while 11A was reduced from 6,681 ML to 3,700 ML and 9A north from 3,835 ML to 2,400 ML.

- The limited access to the groundwater resource in Zone 11A and 9A north means that users will be unable to access Priority 2, 3 or temporary allocations which may be required for auxiliary purposes, climatic variation or development purposes. Irrigators may have already financially committed to crop development however as the water allocation reductions are instant irrigators may be financially impacted. Some irrigators also purchased water allocation licences which were not developed during the assessment period and therefore received zero allocation under the current arrangement.
- The lowering of the permissible annual volume in Zone 11A was due to the potential salinity risk associated with pumping induced groundwater flow reversal which may result in ingress of saline groundwater into the irrigation development zone. Hydrogeological assessments, including groundwater modelling, have concluded that the salinity risk in this zone is low with potential impacts in the decades to hundreds of years. The decision to transfer water allocations from Zone 11A to 10A is considered to be administrative-based.
- Parilla Red irrigators have received Priority 1, 2 and 3 allocations and a nominal volume (not yet determined as the licencing process is not complete) as temporary auxiliary allocations. The Parilla Red irrigators require additional water on a hectare basis than allowed in the volumetric conversion process. The higher water usage rate is due to local environmental conditions. This additional water can be accessed through the temporary auxiliary allocations if the irrigator can prove that the historical irrigation use is greater than the revised allocation. Despite the increase, the annual allowable volume may not provide irrigators sufficient access to water in low rainfall years even through the temporary auxiliary allocations process.
- The approach adopted in the volumetric conversion process considers local conditions, irrigation efficiency and auxiliary requirements (via temporary allocations) however is considered reasonable. Field trials have not been carried out to confirm the appropriateness of the conversion factors therefore it is recommended that ongoing monitoring be carried out and the factors revised as required. The implementation of the volumetric process is limited by the permissible annual volume. A review of the allowable storage depletion is recommended to enable an increase in the permissible annual volumes.

Recommendations

The following assessments are recommended to confirm findings or assist in revising the WAP:

- Groundwater modelling for the area was carried out in 2006, additional groundwater modelling incorporating metered extraction and monitoring information is recommended to confirm the status of the groundwater resource and any impact associated with the revised water allocation volumes or the impacted of raised annual allowable volumes or additional allowance for auxiliary requirements. Groundwater modelling should be carried out to assess the vertical salinity risk associated with increased groundwater use in Zone 10A.
- Provide a water allocation for auxiliary requirements to all irrigators. If any temporary auxiliary allocations are available after the allocation process in Zone 10A, this allocation should be distributed across the three Zones 11A, 10A and 9A north to provide all irrigators an equitable share of the resource.
- Adopt a phased in approach whereby temporary auxiliary allocations is made available to all irrigators over a five year period to enable irrigators to make necessary adjustments to water management practices and to avoid undue hardship.
- Review the need for a carry-over scheme which would account for variations in climatic conditions or crop rotation periods.

Contents

Figures & Tables

1 Introduction

1.1 Background

Potatoes South Australia Inc. (Potatoes South Australia) engaged Australian Groundwater Technologies Pty Ltd (AGT) to carry out a review of the water allocations assigned to Border Zones 9A north, 10A, 11A and Management Area Parilla Red as outlined in the Mallee Prescribed Wells Area (PWA) Water Allocation Plan (WAP). The location of the Mallee Prescribed Wells Area is presented in Figure 1.

Potato producers in Zone 10A and Parilla Red have had water allocations reduced by up to 40% while potato producers in Zone 11A have had water allocations reduced by up to 50% from previous years. As these reductions are immediate it has not allowed producers sufficient time to implement new efficient management practices which may have resulted in significant economic hardship. The revised water allocation has resulted in limited crop development in 2013/2014 and subsequent years and does not provide sufficient flexibility for climatic variations. The Mallee produces approximately 80% of the nation's fresh washed potatoes.

The reduction in water allocation coincides with the adoption of the revised Mallee WAP in 2012. The WAP sets out the rules for managing and taking of underground water from within the PWA to ensure that the long-term sustainability of the region's water resources are maintained for all users including the environment. The WAP is developed from a guiding set of principles designed to provide flexibility and equity of access to water in order to sustain the ongoing economic, social and environmental systems that depend on that water.

AGT were commissioned to carry out a review of the equality of the water allocation process and review any scientific basis for the reduction in water allocations in the area. This document presents the findings of this review.

1.2 Scope of work

AGT carried out the following scope of works as part of the review:

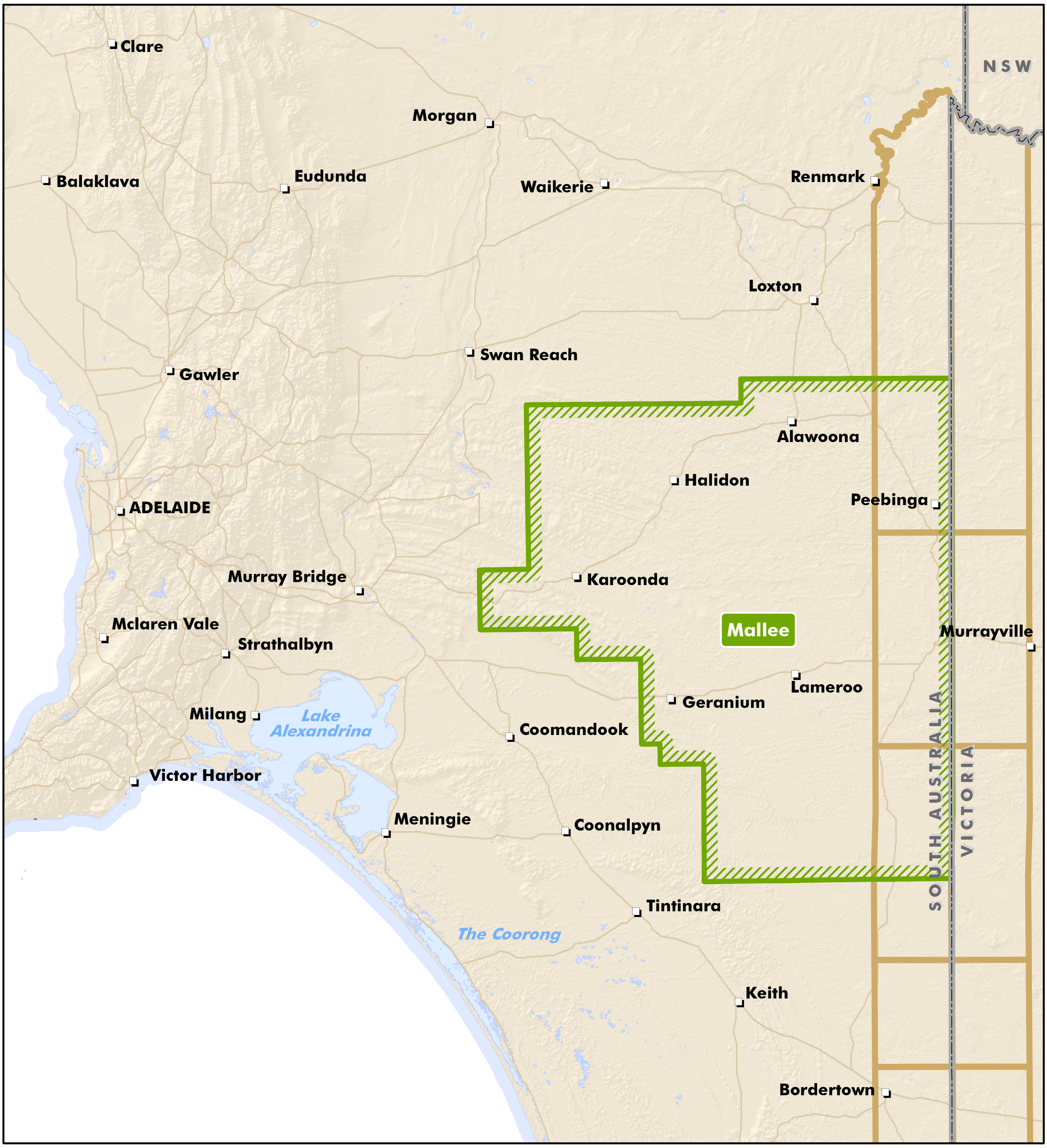
- Review the scientific justification for the Permissible Annual Volume (PAV)/ Annual Allowable Volume (AAV) assigned to Border Zone 11A, 10A, 9A north and Parilla Red Management Area.
- Review the volumetric conversion process implemented as part of the WAP.
- Review the relevance of the management area boundaries and the trade conditions.
- Liaise with stakeholders as required.
- Conduct two stakeholder meetings; one at the start of the project and one following the provision of the Draft Report.
- Liaise with Chief Executive Officer of Potatoes South Australia as required.

- Provide a stand-alone Draft Report to the Chief Executive Officer of Potatoes South Australia including a discussion of the work reviewed, outcomes of the review, conclusions and recommendations.
- Provide a stand-alone Final Report to the Chief Executive Officer of Potatoes South Australia including a discussion of the work reviewed, outcomes of the review, conclusions and recommendations.
- Provide advice concerning next steps including presentation to the Minister for Water and the River Murray.

1.3 Objectives

AGT was engaged to assist Potatoes South Australia and potato producers in understanding the justification and methodology adopted by the South Australian Murray Darling Basin Natural Resources Management Board (SAMDBNRMB) and the Border Groundwater Committee (Committee) in reducing the PAV's and water allocations in the Mallee area.

An understanding of the methodology and justification (both policy and scientific) for the water allocation reduction will assist the producers in understanding the current and future of the groundwater resource, the necessity for any water management measures and if any variations to the WAP can be implemented (e.g. phased reduction) to assist the producers in adjusting to the new allocations without putting at risk economic viability of their properties and the Mallee Industry.



LEGEND

Management Area

Prescribed Well Area

Border Agreement Zone

GDA 1994 | MGA Zone 54

A4 1:1,500,000

0 40

Kilometres

Australian Groundwater Technology does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

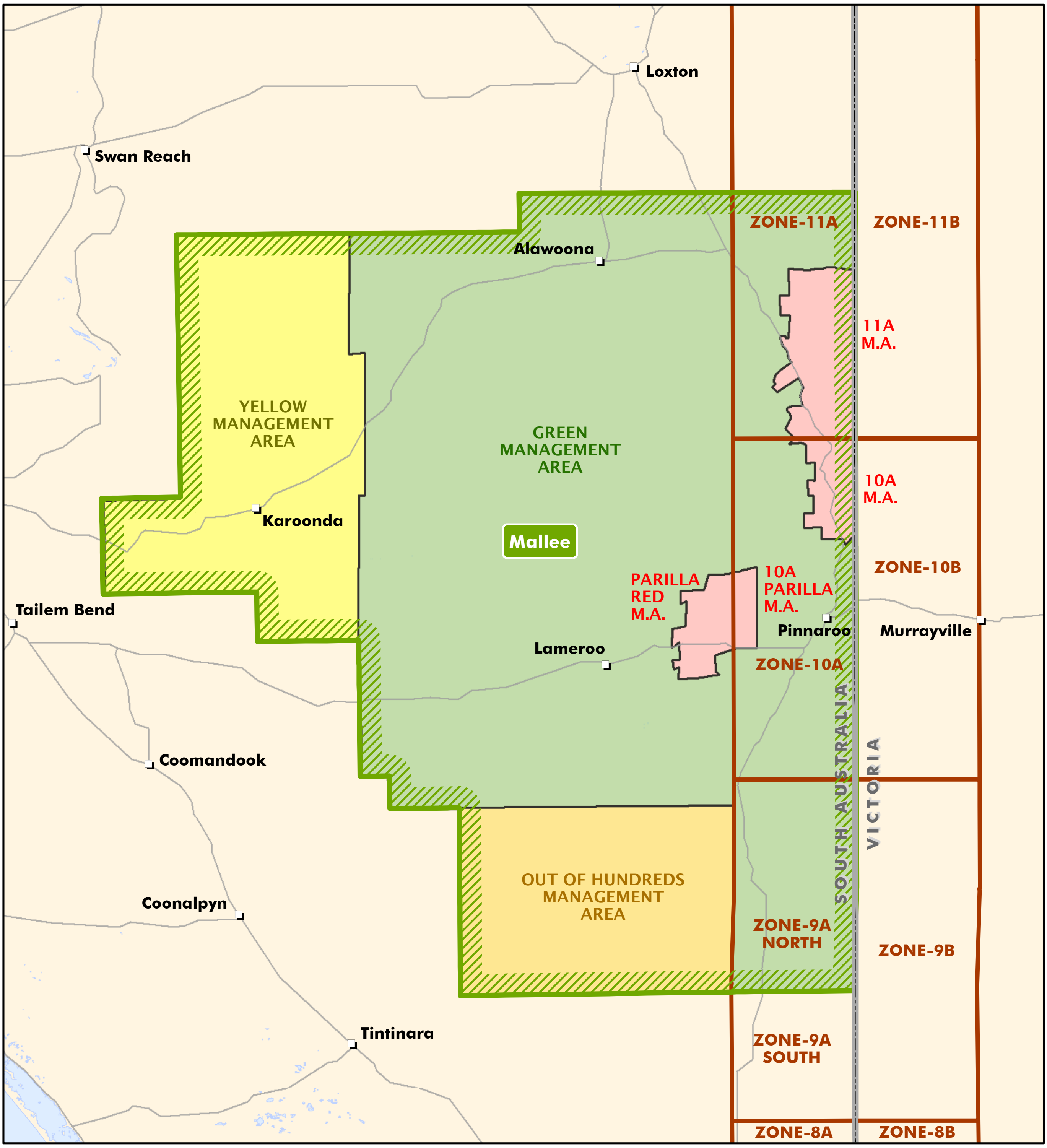
Australian Groundwater Technologies AGT

Figure 1 | Site Location Plan

December, 2013 | P:\(PAN)_Potatoes_South_Australia\Projects\1316-13-PAN_Mallee_and_LLC_PWA_Review\GIS\Maps\final\mallee-locality.mxd

2 Environmental Assessments

AGT carried out a review of available information to assist in the assessment of the groundwater resource, irrigation requirements and policy framework which describe local conditions. Table 1 presents information relating to the hydrogeological conditions of the resource and irrigation practices in the area reviewed as part of this study. There is significantly more information however only relevant and easily accessible documentation has been reviewed to complete this study due to time constraints. The groundwater assessment reports detailed in Table 1 refer to Groundwater Border Zones and Mallee WAP Management Areas, Figure 2 presents the location and boundaries of the zones as a reference however further information pertaining to local policy framework is presented in Section 3.



GDA 1994 | MGA Zone 54

A4 1:940,000

0 20

Kilometres

LEGEND

- Management Area
- Prescribed Well Area
- Border Agreement Zone

Australian Groundwater Technology does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

Australian Groundwater Technologies AGT

Figure 2 | Mallee PWA Border Zones and WAP Management Areas

December, 2013 | P:\(PAN)_Potatoes_South_Australia\Projects\1316-13-PAN_Mallee_and_LLC_PWA_Review\GIS\Maps\final\mallee-management areas.mxd

Table 1: Documentation Review and Key Findings

Document Title	Date	Author	Objective	Key Findings
Five year management review 1996–2000	October 2001	SA/VIC Border Groundwaters Review Committee	The Border Committee is required to review certain management prescriptions at periods not exceeding intervals of five years. This report consolidates the Committee's views in respect of the Permissible Annual Volumes, permissible distance and permissible rate of potentiometric surface lowering.	The review concluded that there were significant drawdowns observed in Zone 10A whilst groundwater use was still within the PAV. The management prescription has been developed which allows for the extraction of an equivalent volume of water based on 0.05 m/a drawdown in an unconfined aquifer. PAVs allocated did not take into account that the aquifer was confined in certain areas. The PAV based on the 0.05 m/a, a specific yield of 0.1 and salinity <3,000 mg/L were calculated for each zone. The review did not identify any discernible change in salinity in the province. Away from areas of concentrated activity there are no regional trends in water level or salinity.
Mallee PWA and Murrayville WSPA Groundwater Monitoring Status Report	2003	Steve Barnett, The Department of Water, Land and Biodiversity Conservation	Annual reporting as part of the Departments responsibility of the state's underground resources.	This review of monitoring trends (both water level and salinity) did not identify any major adverse impacts due to irrigation extractions from the MGL aquifer and confirms the appropriateness of the current management approach. Drawdowns have reached equilibrium where irrigation has been established for some time and extractions are relatively stable. Conversely, in areas where extractions have steadily increased, downward trends are expected to increase indefinitely because there are few unused allocations in the areas of good water quality. Monitoring has confirmed the robustness of the groundwater resource. Salinity trends are stable or decreasing. An area of groundwater flow reversal was identified north of Peebinga with ongoing monitoring recommended.
Mallee PWA – Murrayville WSPA Groundwater Model	December 2006	Steve Barnett and Kwadwo Osei-bonsu	The earlier 2000 groundwater model for the Mallee region was revised to incorporate additional information pertaining to inter-aquifer leakage. The model was used to predict the impact on groundwater levels associated with groundwater extraction in the area. The model	The report described local geology and hydrogeology conditions which included the five main hydrogeological units (aquifers and confining layers); Pliocene Sand Aquifer, Bookpurnong Beds (confining layer), Murray Group Limestone Aquifer (MGL, aquifer targeted for water supply), Ettrick Formation (confining bed) and Renmark Group Aquifer.

Document Title	Date	Author	Objective	Key Findings
			scenarios included current extractions rates (<PAV) and PAV extraction rates.	The following modelling scenarios were carried out: 1) Current extractions (2004–05) in both SA (30,660 ML/yr) and Victoria (4,206 ML/yr) 2) Current PAV in SA (53,000 ML/yr) and current extractions in Victoria (4,206 ML/yr) 3) Current allocations in SA (53,000 ML/yr) and full allocation in Victoria (9,466 ML/yr) 4) Same extractions in SA and VIC Border Zones (at SA PAV rates of 16,000 ML/yr) The flow and salinity model concluded the following: Water extractions in SA do not affect groundwater inflows into the Murrayville WSPA from the south, and do not impede the development of groundwater in Victoria. Only groundwater that is not used flows from Victoria to SA. The cross-border flow into SA during 2004–05 of 1,525 ML/yr represents 0.0001% of the volume of groundwater stored in the MGL aquifer in Zone 10B and 11B. The modelled drawdown impact in Victoria of extraction up to 15,000 ML/yr in Zone 10A, is an extra 3.5 m in the area of maximum drawdown (10 m) near the Border, to 1–2 m at the eastern boundary of Zone 10B. Actual monitoring at the time suggested that the modelling impact was over-estimated and conservative. An increase in Victorian extractions to 16,000 ML/yr to match the SA extractions, increased drawdowns in Zone 10B by up to 10 m and induce flow from SA to Victoria. The pressure level would also drop below the base of the Bookpurnong Beds confining layer in areas of maximum drawdown, leading to unconfined conditions in these areas. Over most of the model area, there were no significant salinity changes predicted due to downward leakage or flow reversal in all modelled scenarios. However in the area of maximum drawdown (and greatest potential

Document Title	Date	Author	Objective	Key Findings
				for downward leakage), small increases of 40 mg/L (4% of salinity at the time) were predicted after 25 years. This increase is smaller than the variation in observed values. Toward the northern boundary of the Murrayville WSPA where salinities in the overlying PSA are high, small increases of 30 mg/L (3%) were predicted after 25 years. This increase is also smaller than the variation in observed values.
Salinity Risk from Groundwater Extractions in the Mallee Region, Technical Note 2007/05	May 2007	Steve Barnett, The Department of Water, Land and Biodiversity Conservation	The Technical Note examines the location, likelihood, consequence and probable timeframes for salinity risks in the Mallee Area.	The risk of salinity increases due to lateral inflows is negligible from east of Murrayville, and low from north of Peebinga. All salinity risks are long term (decades to hundreds of years).
Consultation and Alterations Report Water Allocation Plan for the Mallee Prescribed Wells Area	April 2011	South Australian Murray-Darling Basin Natural Resources Management Board	The report was prepared to summarise the consultation process on the draft WAP for the Mallee PWA and report on the matters raised during consultation and recommended alterations to the Plan as a result.	The consultation report outlines the key alterations to the plan and a response to key issues identified during the consultation process. The alterations, key issues and Department responses are highly detailed and therefore will not be summarised in this document.
Assessment of the Needs of Water Dependent Ecosystems for the Mallee Prescribed Wells Area	April 2012	Jason VanLaarhoven, Department of Water	In accordance with the NRM Act 2004, before determining the capacity of a prescribed water resource, the Minister must prepare a report assessing the needs of ecosystems that depend on the prescribed resource.	Due to the deep unconfined water table, high salinity levels and the paucity of groundwater dependent ecosystems, it is expected that groundwater extractions will have minimal to no impact upon aquatic environments within the Mallee PWA.
Discussion Paper: Volumetric Conversion for the Mallee Prescribed Wells Area	Unknown	EconSearch	The principal objective of the project has been to coordinate a process to achieve agreement from key stakeholders regarding the volumetric conversion for Mallee water licences, which ensures the protection of the	The existing area based allocation system to derive current HalE and Crop Area Ratio (CAR) were developed by Desmier (1991), as referenced by EconSearch. Desmier divided the two areas (Northern and Southern) and calculated different HalE and CAR values for each area. In 2004, Rural Solutions SA reviewed the work of Desmier, updates the estimates and calculated revised

Document Title	Date	Author	Objective	Key Findings
			water resource and meets reasonable irrigator requirements.	figures referred to as Net Irrigation Requirements for a specific range of crops within two areas of the Mallee PWA. This was carried out using long-term average climatic data sourced from the Bureau of Meteorology and using the internationally recognised FAO methodology (Allen et al, 1998). NIR only takes account of water used directly in evapotranspiration. Additional crop water must be extracted to cover application losses, leaching and auxiliary requirements. The Mallee WAP Principle 12 indicated that "Water shall only be allocated for irrigation where the use of the water shall achieve an irrigation efficiency of at least 85%. The **Irrigation Requirement** is therefore calculated by Net Irrigation Requirement (mm)/ Efficiency of Irrigation system (decimal). Auxiliary requirements include control effects of frost, and for soil temperature control for optimal potato storage prior to harvest, irrigation to control sand drift in the early stages and irrigation for crop cooling to avoid head damage. The report presented several allocation calculations and implementation methods and a modelled scenario in order to determine the extent of impact associated with the scenario. A total of five scenarios were considered. Based on the reported information the document presents 17 recommendations, of note: Recommendation 10: If allocations are to be made for auxiliary requirements, then these will be made on the basis of individual application. This recommendation is based on the fact that, analysis of 2004/05 data only a minority of irrigators are using volumes above the amounts that would be allocated under the basic allocation formula. Recommendation 14: If allocations are made for auxiliary requirements, they will be neither permanent nor tradeable. They will be in effect for a period to be determined in the new (now adopted) WAP. The document should be consulted for further discussion and recommendations.
Mallee PWA Groundwater Level and	2010	Department for	Annual reporting as part of the Departments responsibility of the	The 2009–10 Groundwater status report for the Mallee PWA was assigned a green status of "No adverse trends, indicating a stable

Document Title	Date	Author	Objective	Key Findings
Salinity Status Report 2009–10		Water	state's underground resources.	or improving situation" which was supported by a recovery in groundwater levels in areas of concentrated extraction and no significant changes in salinity levels in areas of concentrated extraction where the MGL aquifer is confined. Metered groundwater extraction for licensed purposes (excluding stock and domestic) was 38,438 ML which is a decrease of approximately 10% from the previous year.
Mallee PWA Groundwater Level and Salinity Status Report 2011	2011	Department of Environment, Water and Natural Resources	Annual reporting as part of the Departments responsibility of the state's underground resources.	The 2010–11 Groundwater status report for the Mallee PWA was assigned a green status of "No adverse trends, indicating a stable or improving situation" which was supported by a recovery in groundwater levels in areas of concentrated extraction and no significant changes in salinity levels in areas of concentrated extraction where the MGL aquifer is confined. Metered groundwater extractions for licensed purposes (excluding stock and domestic) were 24,365 ML which is a decrease of approximately 37% from the previous year.
Mallee PWA Murray Group Limestone Aquifer Groundwater Level and Salinity Status Report 2012	2012	Department of Environment, Water and Natural Resources	Annual reporting as part of the Departments responsibility of the state's underground resources.	The 2011–12 Groundwater status report for the Mallee PWA was assigned a yellow status of "Gradual adverse trends, indicating low risk to the resource in the medium term" Continuation of these trends is likely to negatively impact the beneficial use (i.e. drinking water, irrigation or stock water (of the resource for at least 15 years. This is supported by showing that 84% of observation wells show a decline in the maximum groundwater levels recorded in 2012 when compared to 2011, however these declines are typical of a below average rainfall year and does not pose an immediate risk to the resource and little observed change in salinity concentrations in the 17 wells that were monitored. Metered groundwater extractions for licensed purposes (excluding stock and domestic) were 31,736 ML which is an increase of approximately 30% from the previous year. Water extraction is still lower than that observed in 2009–10.
Mallee Prescribed Wells Area Annual Water Use Report 2008–2009	February 2010	Rebecca Arnold, South Australian Murray-Darling	The annual report provides a summary of Annual Water Use Report Forms submitted by licence holders in the Mallee PWA pursuant to Section 8	The metered volume of water used in the 2008/09 year was 45,030 ML which is a decrease of 7,121 ML from the previous year. The inclusion of water for sand mining, an increase in the volume of water used for stock and domestic purposes and a drier rainfall year

Document Title	Date	Author	Objective	Key Findings
		Basin Natural Resources Management Board	of the Water Allocation Plan for the Mallee Prescribed Wells Area (2000).	than average caused a large jump from previous years 2006/07 to 2007/08.
Mallee Prescribed Wells Area Annual Water Use Report 2009–2010	August 2011	Sarah Kuchel, South Australian Murray-Darling Basin Natural Resources Management Board	The annual report provides a summary of Annual Water Use Report Forms submitted by licence holders in the Mallee PWA pursuant to Section 8 of the Water Allocation Plan for the Mallee Prescribed Wells Area (2000).	The metered volume of water used in the 2009/10 year was 40,687 ML which is a decrease of 4,343 ML from the previous year. Irrigation water use was 3,000 ML less than the previous year due to less irrigated crop area grown and in some cases less ML/ha water used. The town water supply use also decreased.
Mallee Prescribed Wells Area Annual Water Use Report 2010–2011	May 2012	Welsh & Campbell, South Australian Murray-Darling Basin Natural Resources Management Board	The annual report provides a summary of Annual Water Use Report Forms submitted by licence holders in the Mallee PWA pursuant to Section 8 of the Water Allocation Plan for the Mallee Prescribed Wells Area (2000).	The metered volume of water used in the 2010/11 year was 26,234 ML which is a decrease from the previous year. Irrigation water use was 11,500 ML less due to high rainfall in this period and as a result of less ML/ha of water used per irrigated crop. Town water supply, sporting clubs, local government, schools all also decreased their use in 2010/2011.
Management Review Tertiary Limestone Aquifer in Province 3 of the Designated Area	January 2010	South Australia – Victoria Border Groundwaters Agreement Review Committee	The Border Committee commissioned a review of management prescriptions with the Province 3 region in response to a lowering of groundwater levels within the Border zone.	The review of recent groundwater and salinity trends identified that the aquifer acceptably responded to the level of use in terms of drawdowns and salinity. There was also no immediate risk of increased groundwater salinity due to the lateral movement of saline groundwater or the vertical leakage of saline water from the Pliocene Sands Aquifer. There is the potential for localised “hotspots” of drawdown, which could increase the impact on domestic and stock users, or increase the risk of dewatering the aquifer or accelerating water quality change. The report concluded that the volumes able to be taken over the next 5 to 10 years will not compromise the quality and availability of this resource.
Twenty Fourth Annual Report	2009	South Australian –	An annual review of groundwater and salinity conditions in the three	Summary of Province 3 It is acknowledged that the groundwater resource is not being

Document Title	Date	Author	Objective	Key Findings
		Victorian Border Groundwaters Agreement Review Committee	Provinces of the Groundwater Border Zone.	replenished by modern recharge and has been managed as a non-renewal source since 2001. Groundwater levels had declined with cones of depression forming around areas of intense irrigation development. Groundwater level drawdowns in the summer of 2007/08 were double those in previous years however were associated with an increase use due to a low rainfall year. The drawdowns were of concern due to the potential for loss of water supply to groundwater users, particularly stock and domestic. The Committee commissioned the Management Review of Province 3 to further assess the sustainability of groundwater extraction and any salinity risks.
Twenty Fifth Annual Report	2010	South Australian – Victorian Border Groundwaters Agreement Review Committee	An annual review of groundwater and salinity conditions in the three Provinces of the Groundwater Border Zone.	Summary of Province 3 Based on the Management Review report, no amendments to the management prescriptions were recommended. As part of the Mallee WAP conversions from hectare to volumetric based water allocations, the Committee realigned the PAVs in Province 3 without increasing the aggregated PAV to assist SA in implementing the WAP. The committee noted that the amendment to the PAVs was carried out to allow for the conversion of licenses from area based entitlement to volumetric based entitlement and to encourage a wide distribution of water by facilitating the reduction in the areas of concentrated irrigation development. The following PAVs were adopted: Zone 11A – from 6,861 ML to 3,700 ML; Zone 10A – from 9,400 ML to 14,000 ML; Sub Zone 9A North – 3,835 ML to 2,400 ML
Twenty Sixth Annual Report	2011	South Australian – Victorian Border Groundwaters Agreement Review Committee	An annual review of groundwater and salinity conditions in the three Provinces of the Groundwater Border Zone.	Summary of Province 3 Intense groundwater development began after 2001 and the observed long-term water level trends and seasonal drawdowns are consistent with the pressure response of pumping in a confined aquifer. A seasonal cone of depression has formed with its centre located at Peebinga, an area of intensive groundwater extraction. The aquifer is responding as expected to the level of use, in terms of drawdown and salinity however the full potential response of the aquifer is yet to be realised as groundwater extraction in Victoria is less than the PAV. There is no immediate risk of increased

Document Title	Date	Author	Objective	Key Findings
				groundwater salinity due to either the lateral movement of saline groundwater or vertical leakage of saline water from the Pliocene Sands Aquifer.
Twenty Seventh Annual Report	2012	South Australian – Victorian Border Groundwaters Agreement Review Committee	An annual review of groundwater and salinity conditions in the three Provinces of the Groundwater Border Zone.	Summary of Province 3 The annual report concluded that there is no immediate risk of increased groundwater salinity due to either the lateral movement of saline groundwater or the vertical leakage of saline water from the Pliocene Sands Aquifer.
Twenty Eighth Annual Report	2013	South Australian – Victorian Border Groundwaters Agreement Review Committee	An annual review of groundwater and salinity conditions in the three Provinces of the Groundwater Border Zone.	The annual report concluded that there is no immediate risk of increased groundwater salinity due to either the lateral movement of saline groundwater or the vertical leakage of saline water from the Pliocene Sands Aquifer.

Table 2: Groundwater Use (ML)

Zone	Groundwater Use (ML)							
	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013
Zone 11A	3,322	3,243	3,575	4,256	3,360	2,937	2,346	2,947
Zone 10A	13,470	14,149	12,172	9,458	9,096	6,394	8,541	9,605
Zone 9A	2,042	2,744	3,812	9,113	8,925	6,092/1,320 North	8,077/986 North	839 North
Total	**18,834**	**20,136**	**19,559**	**22,827**	**21,381**	**15,423/10,651**	**18,964/11,873**	**13,391**
Parilla	6,774	8,166	9,682	7,926	7,984	5,487	–	–

3 Policy Framework

3.1 Border Groundwater Agreement

The groundwater resource along the South Australian – Victorian Border is shared between the two states; in order to manage the resource both states entered into the Border Groundwaters Agreement in 1985. The agreement was updated in 2006.

The agreement establishes a Designated Area, extending 20 km either side of the border, and from the coast to the River Murray. The agreement applies only to the Designated Area which is further divided into 22 management zones with 11 zones in South Australia and 11 zones in Victoria. The South Australian Border Zones 11A, 10A and 9A north which are located in the Mallee PWA and which are also referred to as Province 3 are presented in Figure 2.

The agreement provides that the available groundwater shall be shared equitably between the two states and applies to all existing and future wells within the Designated Area (SAVBGARC, 2009). Stock and domestic wells are excluded from the agreement.

The Border Review Committee (Committee) was established under the Border Agreement as the operating body for the effective implementation and administration (SAVBGARC, 2009). The Committee is responsible for determine the Permissible Annual Volumes for the groundwater resource in each region.

In 2001, The Committee's PAV's for each area were calculated on the following assumptions:

- Vertical or through flow recharge is considered zero;
- A reduction in storage of 0.05 m/a, if the aquifer were unconfined;
- Suitability of water for irrigation, less than 3,000 mg/L; and
- Groundwater extraction in areas of national parks was not carried out.

Based on these assumptions the following PAVs were calculated:

Zone 9A

Zone 9A was subdivided into three sub-zones; 9A north (confined); 9A (south and central confined) and 9A south unconfined. Zone 9A north is the cleared portion in the north which has a calculated volume of 470 ML/a. Sub-zone 9A covered the portion of native vegetation adjacent to the cleared southern portion, the calculated volume for both the 9A south confined and unconfined was 6,495 ML/a. Subsequently, Zone 9A was subdivided and 9A north was assigned a PAV of 3,835 ML.

Zone 10A

Zone 10A is confined with small portions of the zone covered by native vegetation. The calculated volume for this area would be 7,844 ML/a however the allocation and commitment at the time was 9,400 ML/a. For this reason the PAV was maintained at 9,400 ML/a.

Zone 11A

Zone 11A is confined with the northern portion of the zone having a water quality greater than 3,000 mg/L. The calculated volume for this area is 5,632 ML/a however the commitment is 6,861 ML/a. For this reason a PAV in the southern portion of 6,861 ML/a was maintained whilst the highly saline area to the north was assigned zero.

On 1 July 2010 (Gazette, p.3265 and 3266) the Committee varied the PAVs:

- Zone 9A for the Tertiary Limestone Aquifer is divided into two sub-zones with an allowable annual volume for sub-zone 9A north of 2,400 ML.
- Zone 10A for the Tertiary Limestone Aquifer the PAV for Zone 10A shall be 14,000 ML.
- Zone 11A for the Tertiary Limestone Aquifer the PAV shall be 3,700 ML.

Based on the information provided in the annual reports, water use information, WAP and discussions with Neil Power, DEWNR (former Border Committee member) the PAV of each of the zones was varied to assist South Australia in converting from area based to volumetric water allocations and to assist in irrigation development. The overall aggregated PAV was not varied (SAVBGARC, 2010).

The PAV in Zone 9A north was reduced to groundwater use allowing the transfer of 1,435 ML into Zone 10A. The justification for the water allocation transfer was based on unused/ inactive water allocations which would allow for further irrigation development in Zone 10A.

Zone 11A was reduced by 3,161 ML which was then transferred into Zone 10A. The PAV reduction was implemented as a management measure to mitigate against groundwater flow reversal north of Peebinga and to ensure that saline groundwater, to the north, does not ingress into the irrigation development zone. The methodology adopted in calculating the Zone 11A PAV is not clearly documented, however is generally in line with water usage in the WAP assessment period, 1 July 2004 to 1 July 2009 (refer to Section 3.2). Water use in this period ranged between 3,243 ML in 2006–2007 to 4,256 ML in 2008–2009.

3.2 Water Allocation Plan

The Mallee WAP was adopted on 2 May 2012 following a lengthy review and consultation period (commencing in March 2004) and replaced the previous plan adopted on 21 December 2000. The Mallee WAP covers a large portion of the Murraylands area in South Australia and also extends into the Border Groundwater Agreement's Designated Area. The area is referred to as the Mallee PWA and is presented in Figure 2.

Aspects of the Water Allocation Plan which are irrelevant to this review will not be summarised in this Section. Further information can be sought from the Water Allocation Plan available from SAMDBNRMB.

3.2.1 Assessment of the capacity of the resource to meet demands

A management decision was made to allow controlled depletion of the Murray Group Limestone Aquifer due to the slow moving, robust nature of the aquifer and the large amount of storage. After taking the derived inflows, outflows and inter-aquifer leakage volumes from the groundwater model (Barnett and Osei-bonsu, 2006), the extraction of 61,300 ML each year would lead to a depletion of 15% of the total resource volume of water in storage after 300 years. Overall the impacts of extracting 61,300 ML are acceptable both in the short and long term (SAMDBNRMB, 2012).

3.2.2 WAP Management Areas

Irrigation in the Mallee PWA has been established for some time with water levels fairly stable and cones of depression remaining static. Management zones have been established, each with an assigned AAV, to prevent further irrigation developed in particular areas and consequently drawdowns. The AAV in the Border Zones is equal to the PAVs.

The Management Areas assist in the water allocation and transfer process. For the purpose of transfer criteria, this is to ensure that water is only transferred within areas of equal stress or alternatively from areas of high stress to low stress without impacting the AAV for the Management Area.

The Parilla Red Management Area boundary was placed around the area of intense groundwater use. The management was defined around this zone of increased drawdown and resource stress as a mechanism to prevent transfer into an already stressed area. Existing transfer rules regarding well interference would be sufficient to inhibit transfer allocations into the area however for the purpose of defining this area in the WAP an administrative boundary was developed. The Management Areas are presented in Figure 2.

3.2.3 Water Allocations

The annual allowable volume of water allocations for each Management Area is presented in Table 3.

Table 3: Management Areas and AAV (Mallee Water Allocation Plan, 2012)

Management Area	AAV (ML)
Green Management Area (Outside of Designated Area)	25,700
Parilla Red Management Area	7,000
Yellow Management Area	7,000
Out of Hundreds Management Area	1,500
Border Zone 11A (PAV = 3,700 ML) (11A Red Management Area) (11A Green Management Area)	 3,500 200
Border Zone 10A (PAV = 14,000 ML) (10A Red Management Area) (10A Parilla Red Management Area) (10A Green Management Area)	 6,000 3,000 5,000

Management Area	AAV (ML)
Border Sub-zone 9A north (PAV=2,400 ML) (9A North Green Management Area)	2,400
Total Permissible Annual Volume	**61,300**

The Management Areas considered under this review, Border Zone 11A Red, Border Zone 10A Red, Border Zone 9A north and Management Area Parilla Red are fully allocated with the exception of Parilla Red which has a water allocation held by the Minister for Temporary Auxiliary Allocation (TAA). The licencing process in all areas is not yet complete.

An allowance of 42,920 ML over 10 years has been assigned by the Minister for sand mining operations. The water usage has been taken into account during the allocation process and is not included in the AAVs.

Stock, domestic, dryland crop spraying and firefighting groundwater uses are not accounted for in the AAV as the volume is considered insignificant compared with the AAV.

3.2.4 Volumetric conversion for irrigation allocations

As part of the revised WAP, all developed area based irrigation allocations (also referred to as HaIE) were converted to a volume allocation referred to as Conversion Volume. The conversion volume is calculated by:

Conversion Volume = Base Allocation + Crop Area Ratio component (CAR) + Delivery component

Whereby:

Base allocation = Developed HaIE x Net Irrigation Requirement (NIR) of the crop

Crop Area Ratio = CAR is a ratio between the volume of water required for the reference crop compared to the volume required for a particular crop type grown. The CAR component was only applied where the revised CAR decreased by more than 5% to the previous CAR, during the review from Desmier rates (FAO#25) to Skewes rates (FAO#56) (refer to Table 4 in Section 2)

Delivery component = a volume provided to ensure the crop received its NIR whilst some of the unavoidable water losses are provided for, such as losses through irrigation systems due to site characteristics and variable climatic conditions. For the purpose of volumetric conversion, an 85% irrigation efficiency target is considered appropriate.

The conversion volume for individual irrigation allocations was calculated on the maximum area (in hectares) under irrigation during a single water use year within the assessment period, 1 July 2004 to 30 June 2009.

The irrigation requirement for potato crops grown in the Mallee PWA is detailed in Table 4.

Table 4: Irrigation Requirements as adopted in the Volumetric Conversion Process

Crop Type	IR Desmier (mm/Ha/crop)	+CAR Desmier	NIR Skewes (mm/Ha/crop)	+CAR skewes	% change in +CAR
Northern Area (average)					
Reference Crop	1,052	1	1,180	1	n/a
Potatoes (summer harvest)	561	1.88	704	1.68	-12%
Potatoes (winter harvest)	331	3.18	507	2.33	-37%
Southern Area (average)					
Reference Crop	868	1	1,020	1	0%
Potatoes (summer harvest)	472	1.84	611	1.67	-10%
Potatoes (winter harvest)	281	3.09	445	2.29	-35%

A revision of the method (Desmier (1991) by Skewes (2004), as reported in EconSearch) identified an increase in the NIR for the reference crop. This increase was due to the effectiveness of the rainfall being reconsidered from 100% to 65%. An increase in the NIR means that the crop requires more water. The work carried is specific to the Mallee PWA region and is considered acceptable for the conversion process. Field trials have not been carried out to confirm the appropriateness of the conversion factors therefore it is recommended that ongoing monitoring be carried out and the factors revised as required.

Where the sum of the conversion volume allocations for a management area exceeds the AAV, then proportional variations to the conversion volumes will be made until the management area's AAV is reached.

The priority order of allocation is as follows:

- Priority 1 – Development of HalEs during the assessment period (1 July 2004 to 30 June 2009).
- Priority 2 – Development of HalEs post the assessment period (1 July 2009 to adoption of the plan).
- Priority 3 – Undeveloped HalEs (no development between the assessment period and the date of adoption of the plan).

Where the conversion volume allocation is less than the Management Area's AAV (i.e. Parilla Red) then temporary auxiliary allocations (TAAs) may be available subject to the following:

$$TAA\ (ML) = \frac{Individual\ Conversion\ Volume}{\begin{array}{c}The\ sum\ of\ all\ conversion\ volumes\ and\ existing\\ volumetric\ licences\ within\ the\ management\ area\end{array}}\ x\ Volume\ of\ TAA\ available$$

A TAA shall only be granted where the historical use of the licence holder is greater than the licensee's volumetrically converted water allocation.

The TAA is composed of the following three components:

- The first component will be 20% of the total TAA and will expire at the end of the first water use year after the adoption of the plan.
- The second component will be 40% of the total TAA and will expire at the end of the second water use year after the adoption of this plan.
- The third component will be 40% of the total TAA and will expire at the end of the third water use year after the adoption of this plan.

The process of licence allocation is currently incomplete however it is considered likely that Zones 11A and 9A north will only receive Priority Allocations 1 while Zone 10A may receive Priority Allocations 1, 2 and 3 and a TAA. Parilla Red Management Area has received Priority Allocations 1, 2 and 3 and a TAA.

3.2.5 Transfer of Water Allocations

Transfer of water allocations between Management Areas has been enabled to allow reasonable access to water for all users. The transfer may be permanent or temporary however must be sustainable and not interfere with existing developments. Water is only transferrable within areas of equal stress or alternatively from areas of high stress to low stress without impacting the AAV for Management Areas. The AAV for each Management Area must not be exceeded by the transfer.

Table 5 details the allowable transfers between management zones. Areas of intense groundwater extraction, Parilla Red, Zone 11A Red and Zone 10A Red, are considered areas of stress and transfer restrictions exists.

Table 5: Maxtrix for transfer between and within Management Areas (Mallee Water Allocation Plan, 2012)

From To	Green	Parilla Red	Yellow	Out of Hundreds	11A Red	11A Green	10A Red	10A Parilla Red	10A Green	9A North Green
Green	✓	✓	X	X	✓	✓	✓	✓	✓	✓
Parilla Red	X	✓	X	X	X	X	X	X	X	X
Yellow	X	X	✓	X	X	X	X	X	X	X
Out of Hundreds	X	X	X	✓	X	X	X	X	X	X
11A Red	X	X	X	X	✓	X	X	X	X	X
11A Green	✓	✓	X	X	✓	✓	✓	✓	✓	✓
10A Red	X	X	X	X	X	X	✓	X	X	X
10A Parilla Red	X	X	X	X	X	X	X	✓	X	X
10A Green	✓	✓	X	X	✓	✓	✓	✓	✓	✓
9A North Green	✓	✓	X	X	✓	✓	✓	✓	✓	✓

4 Discussion

4.1 Border Agreement Zone 11A

Border Zone 11A is sub-divided into two sections, Zone 11A north which consists of saline groundwater (>3,000 mg/L) and Zone 11A south which experiences intense groundwater use. The zone consists of two WAP Management Areas, 11A Red and 11A Green, refer to Figure 2. For the purpose of this review Zone 11A north and 11A Green will be disregarded due to limited groundwater extraction.

Irrigation development around Peebinga has resulted in a permanent groundwater depression in the area and subsequent flow reversal. As a result of this flow reversal, saline groundwater has the potential to ingress into the irrigation development area and impact local groundwater supply water quality. Groundwater modelling and subsequent groundwater information reviews have concluded that there is no immediate risk within the next 5 to 10 years at current extraction rates. This risk was considered to be long term (decades to hundreds of years, DWLBC, 2007).

In drier years, 2007–2008, groundwater levels in the Peebinga area were observed to drawdown double that observed in previous years. A review (January, 2010) commissioned by the Border Committee concluded that water level and salinity trends were consistent with that modelled in 2006 (Barnett and Osei-bonsu) and there was no immediate salinity risk. Salinity monitoring carried out by on MCG7 located north of Peebinga identifies a stable to slightly declining salinity trend.

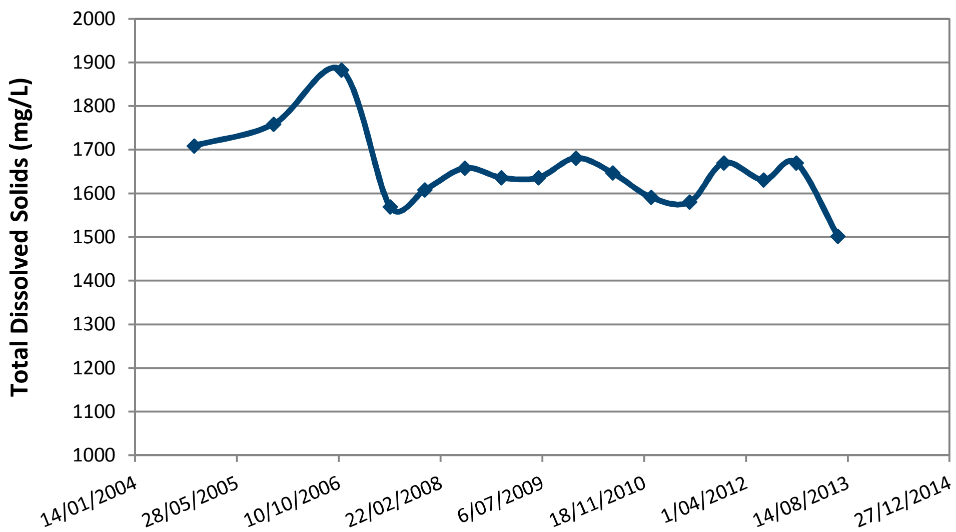


Figure 3: Groundwater salinity monitoring MCG7 located north of Peebinga

In 2010, the PAV for Zone 11A was revised under the Border Groundwater Agreement sighting the risk of saline groundwater ingress and an allowance for greater irrigation development in Zone 10A, located to the south. Due to the long term nature of the salinity risk, it is inferred that the PAV was reduced as a socio-economic decision to allow for greater irrigation development in Zone 10A and is not based on scientific evidence alone. The PAV was reduced from 6,861 ML to 3,700 ML which is similar to that used by irrigators during the nominated assessment period, groundwater usage ranged between 3,243 ML in 2007 to 4,256 ML in 2009. The reduction has resulted in further irrigation development of 3,161 ML in Zone 10A based on the aggregated overall PAV in the Border Zones remaining the same.

As a result, water allocations in this zone have been reduced to be in line with the revised PAV. Some irrigators have received up to a 50% reduction in current allocations. Local potato irrigators have indicated that the reduced water allocation will limit future business development and potentially have financial implications especially where water licenses were purchased and have received zero allocation.

As recommended in the EconSearch report, the volumetric conversion calculation should include auxiliary requirements for various crops in order to manage frost or soil moisture requirements. Potato crops are an example of a crop where irrigators report applying significant volumes of auxiliary irrigation. In particular, there is a need for irrigation prior to sowing, to assist in preparation of planting beds, followed by frequent irrigations from planting onward, before the seed pieces have sprouted, and this before any evapotranspiration begins. Dry soil at this time will severely reduce emergence of potato plants.

Once the potato crop matures, the foliage is chemically killed or dies off naturally, and hence no evapotranspiration occurs, yet the soil must be kept moist until harvest, to preserve the quality of the mature tubers. Irrigators report that this in-ground storage may last for more than a month and in some cases be extended for two to three months. Auxiliary requirements are not considered in the NIR calculation and need to be considered separately, the volume of water required will vary between crop, season and location. (EconSearch).

The WAP did not consider auxiliary requirements in the volumetric conversion calculation however did include the provision of TAA where the volumetric conversion is less than the AAV/PAV. This provision does not apply to Zone 11A as it has been fully allocated under the revised PAV. If TAA was made available in this zone, irrigators would need to prove historical water use greater than the licence allocation.

The groundwater resource in the area is considered to be robust, despite little to no modern recharge. An extraction volume of 61,300 ML in the Mallee PWA area each year would only deplete 15% of the total resource after 300 years. Based on the same assumptions, Zone 11A is calculated to have 5,632 ML available for extraction while only depleting 15% the resource. Based on a review of the groundwater resource and equability between groundwater users, a PAV of 5,632 ML for Zone 11A is recommended at a minimum. Additional consideration should be given to a higher extraction rate (>61,300 ML) across the Mallee PWA. Ongoing monitoring and updated groundwater modelling will assist in predicting the condition of the groundwater resource in the area.

4.2 Border Agreement Zone 10A

The groundwater resource PAV in Zone 10A has been increased from 9,400 ML to 14,000 ML in order to support irrigation development in the area. The Border Zone consists of two areas of intense groundwater use, 10A Red and 10A Parilla Red. The increase in allocation has been transferred from Zone 9A north and Zone 11A so that the aggregated PAV across the Border Zone remains the same. The 2013 Border

Committee annual report indicates that to 30 June 2013 of the 14,000 ML only 10,756 ML was allocated across 49 licences and that the volumetric conversion had not been applied. The conversion process is to be completed by 30 June 2014 which may result in additional water allocations, licences or TAA. It is currently unclear which management areas within Zone 10A will receive the unallocated water.

Downward leakage into the aquifer from the overlying Pliocene Sand Aquifer containing saline groundwater as a result of irrigation induced drawdown is considered a risk in Zone 10A. Increased groundwater extraction and consequently increased drawdowns has the potential to increase the downward leakage of saline water. Groundwater salinity modelling (Barnett and Osei-bonsu, 2006) was carried out based on a “worst case” scenario which included extractions of 16,000 ML/yr from both the Victorian and South Australian Border Zones. The modelling concluded that an extensive area of potential downward leakage has been created by the irrigation-induced drawdown. The Pliocene Sand Aquifer salinity in the maximum head difference region is in the range of 1,000 to 14,000 mg/L. If leakage is significant, the saline water could migrate slowly down through the confining layer over the next hundred years. Salinity increases associated with increased downward leakage were in the order of 40 mg/L after 25 years. The impact associated with extraction of 20,100 ML (combined Border PAVs), specifically the increase in extraction in Zone 10A, has not been assessed to date.

Groundwater salinity monitoring carried out in the cone of depression in Zone 10A is presented in Figure 4. Monitoring data indicates that salinity appears to be increasing by in excess of 40 mg/L since 2000 under current extraction regimes. A review of the potential impacts associated with the increased PAV in Zone 10A and consequently the increased drawdowns is recommended.

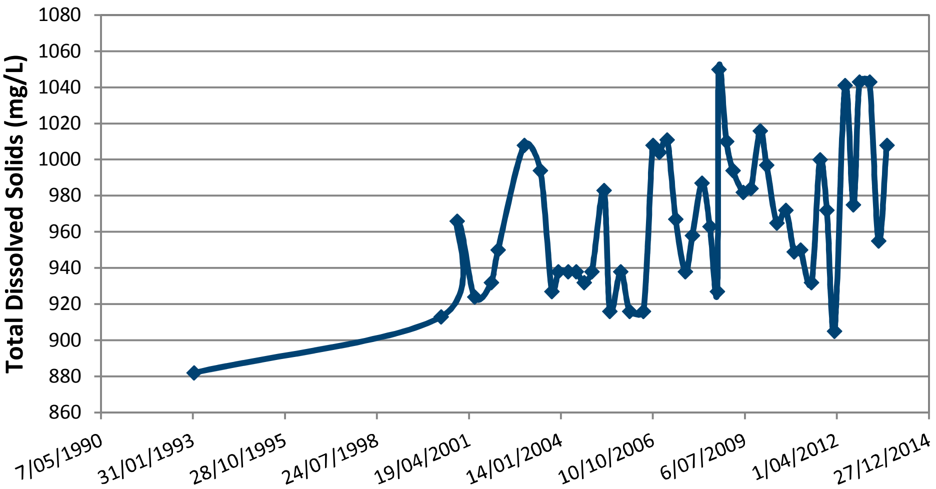


Figure 4: Groundwater salinity monitoring PEB24

4.3 Border Agreement Zone 9A North

On the 15 October 2009, Zone 9A was subdivided into Zone 9A north and Zone 9A south. The Tertiary Limestone Aquifer in the cleared land south of the Ngarkat Conservation Park is partly confined and partly unconfined and as a result, different methods of calculation were used to determine the available resource. The boundary of the confining layer is gradational in this area. Zone 9A was divided in two zones, one north of the Conservation Park and one south. The PAV in Zone 9A north was revised from 3,835 ML (2007) to 2,400 ML (2010) to allow for the realigned PAVs across the Border zones and to allow for greater irrigation development in Zone 10A. The PAV is considered suitable to meet current demand; 839 ML across three licences in 2012–13 and is fully allocated. However it has the potential to limit future irrigation development in the area.

4.4 Parilla Red Management Area

The Parilla Red Management Area is not located within the Designated Area of the Border Zone. This Management Area has been assigned an AAV of 7,000 ML which is similar to average groundwater extractions in the Parilla Hundred area between 2009/10 of 7,984 ML and 2010/11 of 5,487 ML. In low rainfall years (i.e. 2007) groundwater use could be in the order of 9,682 ML however it was noted by SAMDBNRMB that water usage in this year was considered extreme with some irrigators using water at rates far in excess of typical per hectare rates for the crops grown. Groundwater extraction post 2011 is currently not reported. The total water allocations during this period were 3,928 ML in 2010/11 and 3,944 ML in 2009/10 which indicates that the use was in excess of the water allocation during this period.

Personnel correspondence with Sarah Kuchel, Senior Project Officer at SAMDBNRMB, identified that the AAV was derived by local groundwater drawdown conditions and the average groundwater extraction in the area. This PAV allows for the allocation of all Priorities 1, 2 and 3 and in addition allows a portion of TTA which is designed to assist irrigators in adjusting to the revised allocations. In this area the volumetric conversion process has resulted in a lower volume per hectare than irrigators consider necessary for the crops. The conversion process adopted is based on typical local conditions however the appropriateness has not been confirmed with field trials. Ongoing monitoring may identify that particular areas require additional water per hectare due to local environmental factors. The same conversion method was adopted across all areas to ensure equality across the region. If additional water is required for auxiliary purposes the administrative process is through application for a TAA. The AAV of 7,000 ML may not provide irrigators sufficient access to water in low rainfall years even through the TAA process.

Water level trends in the Hundred of Parilla are considered stable (based on monitoring well PLL14) (SAMDBNRMB, 2011). The 2012 groundwater status report for the Mallee PWA reported a general decrease in water levels by less than 0.5 m in the Parilla region. Salinity conditions were not reported.

4.5 Management Boundaries and Transfer of Allocations

Management Areas within the PWA were established as administrative boundaries in order to assign AAV/PAVs, procure the water allocation process and to enable transfers. The Red Management Zones (11A Red, 10A Red, 10A Parilla Red and Parilla Red) were assigned around the areas of intense groundwater use and consequently cones of depression to prevent further irrigation development in the area. The Management Zones are purely administrative to ensure that the groundwater resource is not highly stressed.

Transfer of water allocations is limited to areas of equal stress or alternatively from areas of high stress to low stress without impacting the AAV for the Management Area. Limiting the transfer of allocations into stressed areas (Red Management Areas) is required to sustainably manage the groundwater resource. Alternatively, if transfers were considered sustainable, the AAV/PAV for the management zone could be revised to include this allocation. The principles surrounding transfer of water allocations are considered in the best interest of groundwater resource management for the Mallee PWA.

4.6 Water Allocation "Carry Over Credits"

The use of carry over credits was considered during the WAP consultation process however was not considered to be suitable. The consultation documentation indicated that a carry over scheme may be considered once the new water allocation scheme had been implemented for a period of time.

A carry over scheme has been incorporated in the Lower Limestone Coast WAP (SENRMB, 2013), principle 47 where:

- A licence is endorsed with a volumetric water (taking) allocation; and
- DEWNR has received an Annual Water User Report for the preceding water use year by the required date;
- At the end of the preceding water use year the water allocation has not been fully used.

The licensee will be entitled to take (in addition to his/her annual allocation), a volume of water known as a carry over, which will be equivalent to the unused volume of allocation at the end of the preceding water use year, or 25% of the licensee's annual allocation for the preceding year, whichever is less.

Given the robust nature of the groundwater resource in the Mallee area and variability in climatic conditions, the carry over credit scheme should be considered. This will mitigate issues with crop development in drought or low rainfall periods.

4.7 WAP Implementation

The WAP was adopted on 2 May 2012 with the measures imposed instantly and irrigators' allocations were immediately reduced without consideration of a phased in approach. A phased-in approach would allow the irrigators to gradually manage their cropped area over a period of time (indicatively five years) without enduring financial hardship or implementing additional water management measures. The recently adopted Lower Limestone Coast WAP incorporated a two year phased-in approach to accommodate the water allocation reductions.

5 Conclusions and Recommendations

5.1 Conclusions

The review has identified data gaps or insufficient explanation with regards to the development of the PAV/AAV in the Mallee WAP. The following summarises the outcomes and data gaps of the review:

- Monitoring and groundwater numerical modelling has concluded that the Murray Group Limestone Aquifer groundwater resource is robust and sustainable under current levels of extraction. Current extraction rates would only lead to a depletion of 15% of the total resource volume of water in storage after 300 years.
- The Border Committee realigned the PAVs across arbitrary boundaries to assist in allowing irrigation development in particular areas. Despite the alignment the aggregated PAV remained the same which further confirms the robust nature of the aquifer system.
- The realignment will allow for Priority 1, 2 and 3 allocations to be assigned in Zone 10A and possibly allow for additional TAA while Zones 11A and 9A north will likely only received Priority 1 allocations and no TAA. Zones 11A and 9A north will not be receiving equitable shares of the resource.
- The limited access to the groundwater resource in Zone 11A and 9A north results in users will be unable to access Priority 2, 3 or temporary allocations which may be required for auxiliary purposes, climatic variation or development purposes. Irrigators may have already financially committed to crop development however as the water allocation reductions are instant, they may be financially impacted.
- Parilla Red irrigators have received Priority 1, 2 and 3 allocations and a nominal volume (not yet determined) as TAA. The Parilla Red irrigators require additional water on a hectare basis than allowed in the volumetric conversion process. This additional water can be accessed through the TAA if the irrigator can prove that the historical irrigation use is greater than the revised allocation. Despite the increase, the AAV may not provide irrigators sufficient access to water in low rainfall years even through the TAA process.
- The realignment of PAVs is an administrative-based decision to assist irrigation development in targeted areas and is not based on scientific assessment alone. The revised water usage has not been modelled to determine the impact (if any) on the groundwater resource.

5.2 Recommendations

The following assessments are recommended to confirm findings or assist in revising the WAP:

- Groundwater modelling for the area was carried out in 2006. Additional groundwater modelling incorporating metered extraction and monitoring information is recommended to confirm the status of the groundwater resource and any impact associated with the revised water allocation volumes, the impact of raised annual allowable volumes or additional allowance for auxiliary requirements. Groundwater modelling should be carried out to assess the vertical salinity risk associated with increased groundwater use in Zone 10A.

- Provide a water allocation for auxiliary requirements to all irrigators. If any TAA is available after the allocation process in Zone 10A, this allocation should be distributed across the three Zones 11A, 10A and 9A north to provide all irrigators an equitable share of the resource.
- Adopt a phased-in approach whereby TAA is made available to all irrigators over a five year period to enable them to make necessary adjustments to water management practices and to avoid undue hardship.
- Review the need for a carry-over scheme which would account for variations in climatic conditions or crop rotation periods.

6 References

Allen et al, 1998. Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements, FAO Irrigation and Drainage Paper, 56, Food and Agriculture Organisation of the United Nations, Rome.

Department of Water, Land and Biodiversity Conservation, 2003. Mallee PWA and Murrayville WSPA Groundwater Monitoring Status Report 2003. Report DWLBC 2003/29.

Department of Water, Land and Biodiversity Conservation, 2006. Mallee PWA and Murrayville WSPA – Groundwater Monitoring Status Report 2006.

Department of Water, Land and Biodiversity Conservation, 2007. Technical Note 2007/05 Salinity Risk from Groundwater Extractions in the Mallee Region.

Department for Water, 2010. Mallee PWA Groundwater Level and Salinity Status Report 2009-10.

Department for Water, 2011. Mallee PWA Groundwater Level and Salinity Status Report 2011.

Department for Water, 2012. Assessment of the Needs of Water Dependent Ecosystems for the Mallee Prescribed Wells Area.

Department of Environment, Water and Natural Resources, 2012. Mallee PWA Murray Group Limestone Aquifer Groundwater Level and Salinity Status Report.

EconSearch. Discussion Paper: Volumetric Conversion for the Mallee Prescribed Wells Area. Prepared for South Australian Murray-Darling Basin Natural Resources Management Board.

Rural Solutions, 2004. Definition of Irrigation Requirements in the Mallee Prescribed Wells Area. Report to Department of Water, Land and Biodiversity Conservation.

South Australian Murray-Darling Basin Natural Resources Management Board, 2010. Mallee Prescribed Wells Area Annual Water Use Report 2008–2009.

South Australian Murray-Darling Basin Natural Resources Management Board, 2011. Mallee Prescribed Wells Area Annual Water Use Report 2009–2010.

South Australian Murray-Darling Basin Natural Resources Management Board, 2011. Consultation and Alterations Report Water Allocation Plan for the Mallee Prescribed Wells Area.

South Australian Murray-Darling Basin Natural Resources Management Board, 2012. Mallee Prescribed Wells Area Annual Water Use Report 2010–2011.

South Australian Murray-Darling Basin Natural Resources Management Board, 2012. The Water Allocation Plan for the Mallee Prescribed Wells Area.

South Australian – Victoria Border Groundwaters Review Committee, 2011. Five Year Management Review 1996–2000.

South Australian – Victoria Border Groundwaters Review Committee, 2009. Twenty Fourth Annual Report.

South Australian – Victoria Border Groundwaters Review Committee, 2010. Twenty Fifth Annual Report.

South Australian – Victoria Border Groundwaters Review Committee, 2011. Twenty Sixth Annual Report.

South Australian – Victoria Border Groundwaters Review Committee, 2012. Twenty Seventh Annual Report.

South Australian – Victoria Border Groundwaters Review Committee, 2013. Twenty Eight Annual Report.

South East Natural Resources Management Board, 2013. Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area.

Review of the Lower Limestone Coast Water Allocation Plan Allocation Criterion

Prepared for Potatoes South Australia

AGT Report no: 1316-13-PAN(b)
19 December 2013

Australian Groundwater Technologies

AGT

"making water work"

Document Control

Document Title

Review of the Lower Limestone Coast Water Allocation Plan Allocation Criterion

Report no

1316-13-PAN(b)

Prepared for

Potatoes South Australia

Author	**Date**
R Martin	12 Dec 2013

Reviewed by	**Date**
J van den Akker	16 Dec 2013
R Davis Potatoes South Australia	19 Dec 2013

Approved by	**Date**
R Martin	16 Dec 2013

Revision history

Revision No.	Date Issued	Reason/Comments
Version – 1	16 Dec 2013	Final Draft for comment
Version – 2	19 Dec 2013	Final Report

Distribution

Copy No.	Location
1	Potatoes South Australia Inc
2	Potatoes South Australia Inc, Minister Ian Hunter

Note: This is a controlled document within the document control system.
If revised, it must be marked SUPERSEDED and returned to the AGT QA Representative

Statement of Limitations

The services performed by AGT have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. This report is solely for the use of Potatoes South Australia and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided or conditions encountered at the site during the investigation. AGT has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. AGT assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to AGT was false.

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
Unit 5, 1 London Road, MILE END SOUTH SA 5031
PH: (08) 8352 4262
Fax: (08) 8354 3076
www.agwt.com.au

Executive Summary

Industry Issues

Irrigators from the potato industry with extensive holdings within the Lower Limestone Coast Prescribed Wells Area have reviewed the draft (now adopted) Water Allocation Plan and consider that equity of access to water has not been achieved across all users.

Key areas of concern from this industry group include:

- During the conversion from irrigation equivalents to a volumetric allocation a high proportion of irrigators have received a lower entitlement than their previous historical use. In management areas that are designated as over allocated some of these users are facing further cuts making it impossible to grow the same sized crop and therefore making their ventures uneconomic.
- The conversion to volumetric allocations appears to have adopted the previous irrigation equivalent as a base value and then applied concessional volumes in the form of delivery supplements to account for specific industry practices (e.g. frost prevention, soil conditioning).
- It is acknowledged that there is the ability to apply for bridging volumes these are still insufficient given the base allocation did not accurately capture industry practice.
- Recharge assignments, as reported in the water allocation plan, are inconsistent across the various industry groups e.g. forestry is entitled to claim 120% on clear felling for the first year whilst the recharge component associated with the activities of the potato producers group appears to have been ignored.
- The forestry industry has achieved an additional concessional allocation of 17% over and above their identified prior use which is reported as 83% recharge interception for softwood and 78% recharge interception for hardwood plantations.
- Enabling farm forestry allotments of 20 hectare (ha) or 10% presents considerable future risk to the resource and economic viability of properties as these forestry allotments are not required to have an allocation. This is inconsistent with the principles underpinning the intent of the water allocation plan. The impacts of clustered forestry are clearly reported in the water allocation plan (2013) so to allow further development without the need to acquire an allocation is potentially environmentally irresponsible.
- The requirement to force plantation forestry to be more efficient may lead to genetic modifications or applications of chemicals to induce growth which may ultimately be detrimental to the groundwater quality if leaching occurs. The plan is silent on these matters.
- Comments provided by potato producers during consultation appear not to have been incorporated or have been ignored which has resulted in the wide range of inconsistencies in the approach to allocations.

Introduction

Potatoes South Australia Inc. (Potatoes South Australia), on behalf of their members operating within the Lower Limestone Coast Prescribed Wells Area, engaged Australian Groundwater Technologies (AGT) to review the Water Allocation Plan water allocation criteria.

This review of the Lower Limestone Coast Water Allocation Plan Adopted on 26 November 2013 has identified that:

- The Tertiary Limestone Aquifer as a whole is not over allocated and in over 70% of Management Areas there is in fact a Water Account Surplus. Furthermore, not all allocations are extracted; the volume of total available recharge not extracted on a regional basis each year currently exceeds 10% (WAP 2013).

- However, the method of managing the resource via small arbitrarily defined management areas, which do not adequately take into consideration the lateral extent and robustness of the aquifer, inevitably highlights zones where there is a concentration of demand and a resultant over allocation.

- The risk assessment approach used in the water allocation plan is biased towards adopting a management response in areas of over allocation or where resource condition triggers are being exceeded. Climate factors and time taken for a recharge event to reach the water table in areas where the aquifer is some 20 m below ground surface (e.g. Naracoorte Ranges) is not taken into consideration.

- It appears that during the assignment of allocations to plantation forests the 10% environmental allowance has not been taken into consideration which effectively provides for an additional allocation to plantation forestry.

- The threat that forestry poses to ecological and wetland health has been significantly understated in the water allocation plan, and there is further provision within the plan to allow (with permission of the Minister) future plantings to within 20 m of a wetland. The interception of throughflow, the continued year on year drawdown of the forests and the associate salt load that is discharged to the aquifer after clear felling has significant potential to detrimentally impact the adjacent wetland.

- Allowing properties to sub-divide into small allotments (40 ha is minimum allowed by Local Government) presents a risk to the viability of property holdings. This can be seen throughout the Adelaide Hills.

- If the smaller sized allotments of farm forestry proliferate in coming years presents a real threat to existing users. In future years they may be faced with making additional cuts to their entitlements to accommodate the impacts of the farm forestry which is documented as a water affecting activity. This plan provides for continued expansion of forestry without the need to purchase an allocation.

- The existing plan considers only one option for addressing the apparent over allocation and that is via a mechanism of cuts to entitlements which significantly impacts non-forestry users. The non-forestry users are not the cause of the problem, rather it is the concentration of plantation forestry, which research and monitoring has clearly demonstrated.

- Non-forestry irrigators are required to make cuts to allocations before the full extent of the initial management actions (i.e. forestry reduction of 17%) can be assessed due to the lag associated with plantations maturing and clear felling. Clear felling occurs at a rate of 10% of the planted area for hardwood per year and 3% to 5% of planted area for softwoods each year. Note, forestry received an additional 10% allocation as the allocation for the environment was not deducted from their calculated entitlement.

- Other options such as amalgamating management areas or consideration of irrigators using the deeper sub-aquifer units of the Tertiary Limestone Aquifer (e.g. Camelback Member) have not been included. Encouraging irrigators to use the deeper confined sub-aquifer units via policy measures has the potential to reduce the demand on the shallower groundwater system thus reducing the pressure on wetlands.

Recommendations

The following recommendations are made to assist in addressing the inconsistencies in the water allocation plan for the Lower Limestone Coast Prescribed Wells Area.

- The Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area should be completely reviewed due to the inconsistencies identified in the plan including the 20 hectare farm forestry component that does not require an allocation. Industry considers this to be a significant oversight and potentially environmentally irresponsible given the documented impacts of farm forestry.

- The 20 hectare farm forestry, or 10% of area, should be reviewed and must be required to obtain an allocation. This is imperative to prevent detrimental impacts to the resource accruing over time from the possible cumulative expansion of multiple 20 hectare allotments in any given Management Area. The risk is that in the future irrigators will be required to take cuts in their allocations to account for the impacts of the farm forestry.

- Greater recognition needs to be acknowledged concerning the impact of forestry on wetlands and the option of a 20 m setback (albeit at the Ministers discretion) of new forestry and farm forestry allotments from wetlands or other water bodies should be reviewed or deleted from the Water Allocation Plan.

- Consideration should be given to amalgamation of Management Areas based on good science to provide for significantly more flexibility in resource management and better utilisation of the resource.

- Consideration should be given to assessing the capacity of the sub-aquifer units (e.g. Camelback Member) to support irrigation activities rather than forcing cuts to allocation.

- Efforts should be made to spread the plantation forestry footprint over a wider area throughout the south east e.g. if the existing Management Area is to be maintained then each area should be allowed a maximum percentage cover of plantation forestry type. The percentage cover will differ for different Management Areas based on native vegetation occurrence, wetland and other significant water bodies, soil type and depth to groundwater.

- If other deeper sub-aquifer units can sustainably support irrigation non-forestry users should be encouraged, when replacing an existing or adding a new well on their property, to target the deeper sub-aquifer units. This may mitigate the need for any reductions to non-forestry allocations by distributing the demand to a deeper aquifer unit.

- The risk assessment approach should be incorporated and incorporate hydrogeological parameters such as depth to groundwater and the preceding climate patterns. In its present form it appears to be biased toward allocated volumes and aquifer response.
- Consideration should be given to ensuring that in the management areas of Coles, Short and Zone 2A that once an area has been clear felled new forestry plantings should not be allowed until the 8.5% reduction in forestry allocation has been achieved. This would be equitable with the reductions that other non-forestry users are required to make.
- Monitoring should occur over a subsequent two to three year period following the time that the clear felling has been achieved to assess the resource response before instituting any further cuts. There is significant risk that the present approach outlined in the Water Allocation Plan will overshoot the management targets meaning that non-forestry users have had their allocations unjustifiably reduced.
- Adopt the Statewide policy for recharge interception of 85% for the softwoods and hardwood plantations across the Lower Limestone Coast.
- The resource is resilient and extensive but management at the micro scale will present challenges and inconsistencies. Managing over a larger area with boundaries defined using good science provides significantly more flexibility and would also potentially lead to better utilisation of the resource as a whole.

Contents

Appendix A Forestry Allocation Calculation

Hundred of Coles

Hundred of Short

Figures & Tables

1 Introduction

1.1 Background

The groundwater systems of the South East of South Australia supports approximately 100,000 hectares (ha) of irrigated pasture, agriculture, viticulture and some 146,000 ha of softwood and hardwood forestry. Over the past decade considerable work has been commissioned by the South East Natural Resources Management Board (SENRM) or completed by the now Department for Environment, Water and Natural Resources (DEWNR) to develop and update the Water Allocation Plan (WAP) for the Lower Limestone Coast (LLC) Prescribed Wells area (PWA).

The previous WAP for the region was adopted in 2001. Typically, the WAPs are reviewed and updated every five years however the level of complexity associated with management of the groundwater resources across the LLC have resulted in a major revision of the former WAP adopted in 2001. The WAP sets out the rules for managing and taking of underground water from within the PWA to ensure that the long-term sustainability of the region's water resources are maintained for all users including the environment.

The WAP is developed from a guiding set of principles designed to provide flexibility and equity of access to water in order to sustain the ongoing economic, social and environmental systems that depend on that water.

Irrigators from the potato industry with extensive holdings within the LLC PWA region have reviewed the WAP adopted 26 November 2013 and consider that equity of access to water has not been achieved across all users. In particular, in Management Areas (MAs) where reductions may be required because the resource is over allocated, benefits forestry due to the manner in which allocations have been assigned.

The potato producers have repeatedly advised government representatives during the consultation process that the conversion from irrigation equivalents to a volumetric allocation has resulted in a high proportion of irrigators receiving a lower entitlement than their previous historical use. In Management Areas that are designated as over allocated some of these users are facing further cuts making it impossible to grow the same sized crop and therefore making their ventures uneconomic.

The conversion to volumetric allocations appears to have adopted the previous irrigation equivalent as a base value and then applied concessional volumes in the form of delivery supplements to account for specific industry practices (e.g. frost prevention, soil conditioning).

Of further concern to irrigators is whilst all Local Governments allow subdivision to 40 hectares (ha) as a minimum the plan provides for 20 ha allotments or 10% of property for farm forestry without the need to obtain an allocation. This has the potential, over time, to cause a concentration of forestry in areas that result in the same declines in groundwater levels being observed in the MAs of Coles and Short where at least 50% of the MA is covered by forestry.

Potatoes South Australia Inc. (Potatoes South Australia), on behalf of its stakeholders operating within the LLC Prescribed Wells Area PWA, engaged Australian Groundwater Technologies (AGT) to review the Water Allocation Plan (WAP) water allocation criteria.

A representative of Potatoes South Australia wrote to the Minister for Water and the River Murray and Minister for Sustainability, Environment and Conservation, The Honourable Mr Ian Hunter, advising of its intent to have the allocations reviewed and requested that the formal adoption of the LLC WAP be delayed until the work could be completed and findings discussed with the Minister. Despite this request the Minister formally adopted the WAP for the LLC PWA on 26 November 2013 prior to the completion of this report.

1.2 Scope of work

The objective of this work is to assess if the approaches adopted for the allocation of the available groundwater resources were equitable across all users. To complete this project AGT were specifically tasked with the following activities:

- Review all appropriate documentation.
- Liaise as required with the Department of Environment, Water and Natural Resources (particularly Saad Mustafa on matters relevant to the LLC).
- Develop a listing of all reviewed documents.
- Conduct two stakeholder meetings; one at the start of the project and one following the provision of the Draft Report.
- Liaise with stakeholders as required.
- Liaise with the Chief Executive Officer of Potatoes South Australia as required.
- Provide a stand-alone Draft Report to the Chief Executive Officer of Potatoes South Australia including a discussion of the work reviewed, outcomes of the review, conclusions and recommendations.
- Provide advice concerning next steps including presentation to the Minister for Water and the River Murray and Minister for Sustainability, Environment and Conservation.

1.3 Information Reviewed

Over the past decade a significant amount of scientific work has been undertaken including:

- Detailed hydrogeological investigations to better quantify vertical recharge rates, groundwater movement and the hydrostratigraphy of the aquifer systems;
- Salinity and groundwater level changes and identification of the key drivers influencing the groundwater state and condition;
- The quantification of the impacts of forestry on the groundwater resources of the region,

- Understanding and identifying the requirements needed to sustain the function and biodiversity of the regions groundwater dependent ecosystems; and
- Conversion from area based irrigation equivalents into volumetric allocations.

These investigations commissioned either by the South East Natural Resources Management Board (SENRMB) or by the Department for Environment, Water, and Resource Management (DERM) have been undertaken to allow for a better accounting of the region's available groundwater resources and to enable more effective management. Only a selected but relevant number of reports have been reviewed as part of this investigation due to time limitations to complete this project. Table 1 presents a summary of the documentation reviewed and the key outcomes presented within each document.

The focus of the information reviewed has been on the unconfined Tertiary Limestone Aquifer (TLA) as that is the main aquifer used by irrigators across the South East and is the subject of concern to the irrigators.

Table 1: List of documents reviewed during this study

Document Title	Date	Author	Objective	Key Findings
Review of groundwater resource condition and management principles for the Tertiary Limestone Aquifer in the South East of South Australia	2006	Brown, K., Harrington, G., and Lawson J.	Provides a review of the resource condition. Indentifies groundwater recharge and use. Re-evaluation of the existing PAVs.	A detailed review of groundwater level and salinity trends with identification of a minimum period over which trends should be inferred. Qualification of vertical recharge rates for each management area based on the Water Table Fluctuation (WTF) method. From the vertical recharge rates target allocation volumes (TAR) for each Management Area have been derived. It introduces the concept of setting aside 10% of the vertical recharge to sustain groundwater dependent ecosystems
Volumetric conversion in the South East of South Australia: Calculation of the delivery component and bridging volume	2006	Latcham, B., Pudney, S., and Carruthers, R.	Presents the methodology applied to determine the base allocation and also provision of a bridging volume (subject to eligibility criteria) to allow irrigators to adjust practices to work within the new allocation volumes.	Sets out the framework for the base allocation and the various industry specific practices that on average account for the bridging volume. This report also compares typical average crop requirement data against field trials carried out in the south east using different irrigation application methods. These trials were conducted recognising that to simply adopt industry averages of irrigation requirements was not applicable for the south east due to the variability in soil type and subsurface conditions. The aim was to adopt values more appropriate to conditions within the SE.
Integrated water monitoring review of the South East of South Australia – Phase 2	2006b	Martin, R., Howieson, P., Nicholson, B., and Vertessy, D.	Identifies the key drivers influencing resource condition including the influence of surface water drainage. Reviews the ability of the existing groundwater monitoring networks to reliably identify trends.	This study identified areas where the groundwater system was under stress and the key land use activities that may be the cause of the stress. It also assessed the adequacy of the existing groundwater monitoring network to reliably provide information on the resource condition to assess heath of ecosystems and impacts of users. Key areas were identified where the monitoring network was required to be expanded. The report also proposed alternative management zones based on various hydrogeological considerations rather than the existing administrative zones.

Document Title	Date	Author	Objective	Key Findings
A new understanding on the level of development of the unconfined Tertiary Limestone Aquifer in the South East of South Australia	2007	Latcham, B., Carruthers, R., and Harrington, G.	This report incorporates the new water balance calculations to facilitate future water allocation planning for the region. In addition, new methodologies have been developed for estimating both indicative volumetric allocation and indicative extraction at a management area scale, and the volume of water returned as drainage to the aquifer beneath surface (i.e. flood) irrigation.	This report merges the results of two major projects; one on Volumetric Conversion and the other a review of resource condition and Permissible Annual Volumes for the unconfined aquifer. Innovative methodologies have been developed to enable comparisons to be made between total inputs and total outputs of the groundwater balance for each of the 73 unconfined groundwater Management Areas. This data has been matched with resource condition data (water level/salinity triggers exceeded) for each management area, enabling management areas to be categorised according to the data profile.
Primary production to mitigate water quality threats project Zone 1A Numerical modelling study: Conceptual model development	2008	Harrington, N., Chambers, K., and Lawson, J.	A specific model developed to assess the impacts of water quality threats in Zone 1A.	Divides Zone 1A TLA into the respective sub-aquifer units in order to better quantify the recharge and water quality impacts. In general concludes forestry is a significant threat to both water quality and quantity in Zone 1A
The Timber Industry and Lower Limestone Coast Water Allocation Planning: Socio-economic aspects	2008	Econsearch	This report presents a summary of the contribution of the timber industry to regional economic activity and estimates the economic impact on a range of possible scenarios for the timber industry from implementation of the LLC WAP	The report identifies lost opportunities associated with carbon trading (not a confirmed concept at this time) and also that an equivalent reduction of 4 GL/yr in the agricultural sector would only be impacted by $8 million compared to the forestry sector impact to GRP of $11 million. This report is silent on the potential environmental impact forestry has on ecosystems through lowering of groundwater levels, interception of recharge and increased soil salinity for time periods of 30 years or longer.

Document Title	Date	Author	Objective	Key Findings
Accounting for plantation forest groundwater impacts in the lower South East of South Australia	2009	Harvey, D.	This report presents a detailed record of the development of the annualised plantation forest accounting models used in estimating the water budgets of the lower South East of South Australia.	The report is set out in three parts, a background to the issues, development of the assumptions applied in the forest groundwater models, and the actual development of the annualised forest water accounting models. The information is comprehensive although better examples could be given regarding the volume that forests intercept rather than continually expressing it as a percentage of the recharge. Without a clear expression it is difficult to determine if the use has been accounted for. A simple expression such as: Forest allocation (ML/ha) = (volume recharge intercepted (ML) + volume groundwater extracted (ML)). This simple expression is more transparent to users than trying to determine if 83% or 78% of recharge has been included in the calculations.
A response to managing the water resource impacts of plantation forests and the enabling legislation Natural Resources Management Amendment Bill 2009	2009	Construction Forestry Mining Energy Union	Prepared by the CFMEU and presents a social and economic overview of the need to support forestry in the region.	A submission outlining the social and economic benefits that the forest industry brings to the region. The paper summarises the industry activities, number of jobs supported by forestry in the region and the dollars that forestry generates for the region. It makes a broad generalisation concerning trees creating rain as an environmental benefit but this has proven to be a very weak argument.
Water resource impacts of plantation forests: A Statewide policy framework	2009	State Government of South Australia	Summaries the states policy on forestry as a water affecting activity	Presents a consistent framework for how the forestry impacts should be considered when assigning allocations and the science to support the policy framework.
Modelling forestry effects on groundwater resources in the South East of South Australia	2010	Aquaterra Consulting – , Middlemiss, H.	Groundwater numerical modelling to demonstrate the impacts of forestry over the longer term on groundwater resources.	Generally forestry was a primary cause of groundwater level decline in areas where the groundwater table was accessible to plantation roots and associated loss of recharge. The modelling demonstrated that within five years of removal of the plantation the groundwater levels had typically recovered to pre forestry levels.

Document Title	Date	Author	Objective	Key Findings
Lower Limestone Coast PWA groundwater level and salinity status report	2011	Department for Water	Looks at trends in groundwater levels typically over the past three to five years.	General conclusion is that groundwater levels are still declining in those MAs that have a high percentage of forest cover but on the whole the resource condition is stable or improving apart from the MA of Donovans' which is influenced by seawater intrusion.
Lower Limestone Coast PWA groundwater level and salinity status report	2012	Department of Environment, Water and Natural Resources	Looks at trends over a single year 2011 to 2012 which in general shows groundwater conditions are stable or improving.	Very simple assessment and only looks at trends in groundwater levels and salinity over a single year. It is an incorrect assessment as it presents the information that in the majority of the MAs the groundwater conditions are improving. These reports should be aligned to the period required to assess the trigger levels identified in the WAP which requires changes to be identified over the preceding five years.
South Australian – Victorian Border Groundwaters Agreement Review Committee Twenty Eighth Annual Report	2013	Government of South Australia and State Government Victoria	An annual review of groundwater and salinity conditions in the three Provinces of the Groundwater Border Zone.	The annual report identified unallocated water in Zone 2A within the LLC PWA which is held by the Minister. In general the review committee considered the zones to be under stress and action required to adjust plantation forestry allocations and volumes extracted via bores under entitlement. The committee recommended the sub-division of Zone 1A into two sub-zones to prevent any further intensification of extractions in sub-zone 1A south.
Draft water allocation plan for the lower limestone coast prescribed wells area	2013	South East Natural Resources Management Board	Sets out the rules for the management of the available groundwater resources.	Provides a comprehensive summary of the detailed studies undertaken to better understand and allocate the available resources. Provides the rules around the management of the resources and how transfers of allocations are assessed within the various Management Areas.

Document Title	Date	Author	Objective	Key Findings
Development of the plantation forest threshold in the lower limestone coast prescribed wells area	2013	Harvey, D.	This paper provides a summary of the development of the plantation forest threshold and the associated accounting related to water management in the lower South East of South Australia. The development of the forest expansion component in the forest threshold area occurred over several years in the progress towards forest water accounting and management in the South East.	This report has been prepared to assist in explaining the outcome of the processes in arriving at what has become known as the 59,000 ha expansion component of the plantation forest threshold. The relevant policy at this time is that new commercial plantation forest establishment in the lower South East remains a water affecting activity under the 2004 regulation. This regulation requires that the impacts of new plantations on the local groundwater resource are fully accounted for. The plantation forest threshold, and in particular the remainder of the 59,000 ha expansion component, is an essential accounting item in the assessment of recharge impacts of new plantation proposals.
Limestone Coast Region: Development potential for agriculture, forestry and premium food and wine from our clean environment.	2013	Primary Industries and Regions South Australia	Detailed report identifying economic opportunities across the agribusiness sector in the South East including forestry.	There is ample water in the region that can provide extensive opportunities for increased water use. The quantity of water available is however only one factor in determining whether potential for development should be converted to actual development. Allocations endorsed on water licenses within the Limestone Coast have consistently remained in excess of actual demand for water. Of the 1,119 GL of indicative allocations available as at 2010–11 for use each year, actual average demand between 2006 and 2011 was approximately 384 GL or 34%. The main opportunity will come from utilisation of these unused allocations and the change to volumetric conversion will provide opportunities for operation of a water transfer market. Consideration of changes to the way that allocations are determined within, or transferred between, small scale Management Areas would offer greater flexibility if based upon good science of groundwater movement and management.

2 Lower Limestone Coast Unconfined Tertiary Limestone Aquifer

2.1 Summary of the Unconfined Tertiary Limestone Aquifer

The groundwater resources occur in two major aquifer systems; the upper Tertiary Limestone Aquifer (TLA) and the deeper Tertiary Confined Sand Aquifer (TCSA). A detailed description of these aquifer systems, regional groundwater quality, general hydraulic properties, groundwater condition and rates of recharge can be found in Brown, et al. (DWLBC, 2006). The Draft WAP, 2013 and the groundwater level and salinity status reports (DFW, 2011 and DEWNR, 2012) also provide brief but simplified summaries of the hydrogeological properties of the main aquifer systems. As identified in Section 1.3 the main aquifer of concern to the potato industry irrigators is the TLA and this is the focus of the review.

Detailed work on the regional hydrostratigraphy of each aquifer system was undertaken by Martin (2000, DME unpublished) and by Hill and Mustafa (DWLBC, 2004 unpublished) which illustrated that the two main aquifer systems across the Lower South East of South Australia are significantly more complex than previously thought. The TLA and TCSA comprise multiple sub-aquifer units with different hydraulic characteristics and salinity. Characterisation of the TLA and TCSA stratigraphy has been advanced by Lawson, et al. (DWLBC, 2009 unpublished) using surface geophysics with follow-up drilling and down hole geophysical logging to better delineate the sub-aquifer units.

Groundwater movement is controlled by a number of graben features the most notable of which is the Nangwarry High where the TCSA crops out at surface. Other structural features that significantly influence groundwater movement are the west-northwest trending Tartwaup Fault in the lower south east and the northwest trending Kanawinka Fault which occurs north of Penola.

Love (1991) Brown, et al. (DWLBC, 2006) Harvey (DWLBC, 2009) and numerous other investigators have all identified that there is significant spatial variability in vertical recharge to the unconfined TLA. Rates of vertical recharge are highly dependent on surface physiology, soil characteristics, and depth to groundwater which ranges from as little as 3 m below ground level up to 60 m in areas of higher relief.

Martin, et al. 2006 undertook a detailed review of the resource condition and identification of the key drivers influencing groundwater change. This review also included an evaluation of the capability of the existing groundwater monitoring network to reliably capture trends associated with impacts of groundwater use. Additionally, and coincidentally with the work of Brown, et al., 2006 appropriate time frames over which to review resource condition changes (i.e. three, five, or 10 year intervals) were evaluated.

The WAP 2013 and the latest groundwater status reports (DFW, 2011 and DEWNR, 2012) identify the key threats impacting on groundwater levels and salinity in the unconfined aquifer include, below average rainfall resulting in lower annual recharge, high volumes of groundwater abstraction and land use change, in particular forestry, as key drivers impacting on the resource condition. Although, in some localised MAs e.g. Macdonnel, Kongorong and Hindmarsh, groundwater levels have been rising since 2009 which is assumed to be as a result of slightly increased rainfall.

This increase in groundwater levels is contrary to the normal conditions that would occur in a rainfall recharge driven system such as the TLA. Under declining rainfall conditions as demonstrated on the cumulative deviation from the mean annual rainfall plots presented in the resource condition reports, DFW (2011) and DEWNR (2012), groundwater levels are expected to decline; however, the rainfall cumulative deviation from the mean for the nearest gauging station do not support this assumption. The report illustrates that elsewhere in Beachport, Kingston, and Penola, the annual mean rainfall is still trending downwards which would indicate rainfall recharge to be lower than average and therefore groundwater levels in these areas should theoretically be declining. The observed increasing groundwater levels are more likely to be associated with changed landuse practices.

2.2 Groundwater Management in the LLC PWA

The LLC PWA (Figure 1) is an amalgamation of the former Comaum-Caroline, Lacepede-Kongorong and Naracoorte Ranges PWA's. The groundwater resources across the LLC PWA are administered using 61 MAs. These MAs have been defined more for administrative convenience rather than on any hydrogeological or hydrological characteristics. Of the 61 MAs, six are also included as part of the Border Management Zone.

Groundwater management along the South Australian–Victorian Border is shared between the two states. In order to manage the resource both states entered into the Border Groundwaters Agreement in 1985. The Agreement was updated in 2006.

The Agreement establishes a Designated Area, extending 20 km either side of the border, and from the coast to the River Murray. The Agreement applies only to the Designated Area which is further divided into 22 management zones with 11 zones in South Australia and 11 zones in Victoria. The South Australian Border Zones 1A through 6A fall within the LLC PWA (Figure 1).

The agreement provides that the available groundwater shall be shared equitably between the two states and applies to all existing and future wells within the Designated Area (SAV BGARC, 2013). Stock and domestic wells are excluded from the Agreement.

Australian Groundwater Technologies AGT

Figure 1 | Lower Limestone Coast PWA – Unconfined Aquifer Management Areas

December, 2013 | P:\(PAN)_Potatoes_South_Australia\Projects\1316-13-PAN_Mallee_and_LLC_PWA_Review\GIS\Maps\final\llc-unconfined management areas.mxd

3 Policy Framework

3.1 Water Allocation Plan

There has been significant work undertaken across the LLC over the past decade to move towards a robust accounting framework for the management of the available groundwater resources. This has involved:

- A detailed review of recharge processes and rates of recharge to the unconfined Tertiary Limestone Aquifer (TLA) and the Tertiary Confined Sand Aquifer (TCSA);
- Conversion of the former area based allocation (irrigation equivalents per hectare) to a volumetric allocation which is metered;
- Quantification of the impacts of forestry on the groundwater resources of the region and developing an agreed framework to account for those impacts; and
- Quantifying the needs of dependent ecosystems through detailed studies.

Throughout the process the community and industry groups have been extensively consulted. The volumetric conversion process attempted to capture all the industry specific practices to ensure an equitable conversion from irrigation based hectare equivalent water use (HaIE) to a volumetric amount. Where possible the industry specific practices were measured against actual field trials within the region and consideration was given to additional irrigation requirements to account for different soil types and different application methods (spray, drip or flood irrigation).

3.2 Recharge Rates and Allocations

The general principal of sustainability is that the annual rate of net removal of underground water from the unconfined aquifer should roughly equate to the estimated annual average vertical recharge to the water table (Draft LLC WAP, 2013).

Brown, et al. (2006) undertook an extensive review of the groundwater resources across the South East and redefined the permissible annual volume (PAV) to a new total available recharge (TAR). Brown, et al. (2006) adopted a consistent and transparent approach by applying the water table fluctuation (WTF) method to determine the TAR value assigned for each MA. The approach adopted to determine the TAR included a reduction of 10% of the recharge rate to account for throughflow to meet the needs of ecosystems.

This methodology has been tested by Payder, et al. (2009) and Gibbs (2010) as part of the South East Water Sciences review. Both investigations concluded that the approach adopted by Brown, et al. (2006) provided the best available estimation of groundwater recharge rates across the South East.

The South East Water Science Review (Department for Water, 2010) states that there is a need to set extraction limits so that underground water levels are maintained in order to provide for underground water dependent ecosystems (Draft LLC WAP, 2013). Brown, et al. (2006) accounted for this in a bulk manner by subtracting 10% of the calculated recharge rate and setting that aside to meet environmental requirements.

Consequently a risk assessment framework (DFW, 2012) was applied which posed the following question for each management area:

> *Is there the potential for the current levels of allocation and extraction in management areas in the Lower Limestone Coast to lead to (further) declines in water tables and resource quality, which could detrimentally impact the community, industries and ecosystems dependent on the groundwater?*

Various factors were taken into consideration and a new Target Management Level (TML) identified for each MA. The process is described in detail in the draft LLC WAP (2013).

Applying the risk assessment framework resulted in adjustments from the TAR calculated by Brown, et al. (2006) to derive a new TML for each Management Area. Adoption of the new TML resulted in increases to the available allocation volumes in the MAs of Bangham, Beeama, Comaum, Fox, Glenroy, Grey, Joyce, Killanoola, Western Flat and Zone 3A. In all other MAs the TAR was adopted as the volume available for allocation.

Whilst the risk assessment approach is often subjective (i.e. terms such as “intolerable” may have different metrics for different people or users), it is a mechanism gaining significant acceptance in the management of natural resources. However, in the LLC WAP the risk assessment approach as described lends itself to a bias towards adopting a management response in areas of over allocation or where resource condition triggers are being exceeded. Climate factors and time taken for a recharge event to reach the water table in areas where the aquifer is some 20 m below ground surface (e.g. Naracoorte Ranges) is not taken into consideration.

3.2.1 Allocations to irrigators

The conversion model from irrigation equivalents per hectare (HaIE) is reported in Latcham, B., et al. (2006). The agreed assumptions were that all licensees would receive a Base Allocation and a Delivery Component. The base allocation provides for crop irrigation requirements (Skewes, 2006). In addition, some licensees may also have been eligible for a Crop Adjustment Factor that provided for an additional base allocation where, due to initial calculation problems, the existing area based system did not provide adequate allocation.

Now that final allocations have been provided to irrigators it appears that during the conversion from irrigation equivalents to a volumetric allocation a high proportion of irrigators have received a lower entitlement than their previous historical use. In management areas that are designated as over allocated some of these users are facing further reductions making it impossible to grow the same sized crop and therefore making their ventures uneconomic.

As a minimum the potato producers believe the base allocation should be at least 6 ML/ha not the 4.2 ML/ha as was presented on the old irrigation equivalent licences. The conversion to volumetric allocations appears to have adopted the previous irrigation equivalent as a base value and then applied concessional volumes in the form of delivery supplements to account for specific industry practices (e.g. frost prevention, soil conditioning).

Potato producers feel that their standard practice of maintaining soil moisture at field capacity to control crop growth in fact enhances recharge events. The first rainfall is not required to fill up the soil profile as it is already at field capacity and thus there are immediate recharge benefits to the aquifer. Forestry has been allowed a recharge credit of 120% in the first year following clear felling which is against a soil profile that is entirely devoid of any moisture. The acknowledgement of a recharge credit for plantation forestry is because the soil must reach field capacity before a recharge event can occur. Allowing forestry a recharge credit of 120% and the potato producers zero is an inconsistent approach across the allocation process.

The Delivery Component is the volume of water needed in excess of the crop irrigation requirements to account for irrigation system losses (evaporation losses, deep drainage etc.). In certain crop production systems in which it is necessary to use water for other activities, this water will be provided through the Specialised Production Requirements model component. Examples include the following:

- Forestry achieved a concession to account for 120% of recharge in year one after clear felling;
- The viticulture achieved a concession to apply water for frost abatement; and
- The potato industry achieved consideration for the need to use additional water to allow for managing soil stabilisation and erosion prevention but did not receive a recharge credit similar to forestry.

Rather than basing the minimum delivery component on globally accepted efficiencies, data from field trials in the LLC PWA indicated that such efficiencies would be hard to achieve in many areas of the South East due to the shallow porous nature of the soils. Where this is the case the delivery components have been calculated on the requirement of a 'reasonably efficient' irrigator. Latcham, B., et al. (2006). A summary of the volumetric conversion for irrigators together with the forestry allocation calculations is also provided in Latcham, B., et al. (2007).

It is acknowledged that a Bridging Volume is available on application subject to eligibility criteria. This was an additional temporary water allocation designed to give irrigators, who were currently pumping in excess of their new volumetric allocation, time to adjust to the new system. However, it is insufficient to make up the shortfall.

3.2.2 Allocation to forestry

Science has shown that plantation forestry expansion can significantly impact surface water catchment yield and underground water recharge and that, under some circumstances, plantation species can extract water directly from shallow water tables (Benyon and Doody, 2004; Benyon, et al., 2006; Benyon, et al., 2008).

As a consequence significant negotiations have been held with the Plantation Forestry industry over the past decade to come to an acceptable approach to defining the volumetric impacts of forestry on the available groundwater resources of the South East.

In 2009 the Government released its Statewide policy framework into managing the water resource impacts of plantation forests.

"*Plantation forests, regardless of species, can be assumed to reduce runoff (including groundwater recharge) by 85% and access groundwater through direct extraction when the depth to the groundwater table is less than 6 metres*".

This Statewide policy has not been adopted for the LLC WAP. Softwood has an interception efficiency of 83% and softwoods 78%. The WAP was prepared after the release of the Statewide policy so it is unclear why this figure has not been adopted and applied to the forestry allocations.

Whilst it is not abundantly clear in the LLC draft WAP, the 83% of annual recharge estimated to be intercepted by softwood forests and the 78% of recharge intercepted by hardwood forests have been converted to a volume per hectare. A worked example for ease of understanding is presented in Appendix A. In summary the allocation for commercial forestry has been derived as:

(recharge interception/ha + extraction/ha) = total allocation/ha (ML)

Furthermore, forestry has achieved an additional 10% of allocation as it appears that the 10% environmental throughflow allowance has not been deducted from the annual average recharge volume (refer to Appendix A for a worked example).

The recharge interception is based on the adopted recharge rate for each MA (Brown, et al., 2006) and the impact is either 83% for softwoods or 78% for hardwoods. In reading the WAP and supporting background documentation it appears that the extraction component only applies to forests planted after 2004. Figure 2 presents the hydrograph for the observation well NAN19 which clearly shows a significant recovery event following the 1983 Ash Wednesday bushfires. Since forest regeneration there has been a constant downward trend in groundwater levels to significantly lower levels than 1982.

If the TML were set at the 1982 groundwater level as shown of Figure 2 there would be significantly more forestry that would require an extraction licence. The adoption of the 2004 level is however consistent with the Statewide policy release in 2009.

Figure 2 illustrates clearly the persistent impact that forestry has on the groundwater levels unlike under irrigation which has seasonal recoveries groundwater beneath forestry results in a continual decline that intercepts throughflow and strands wetlands. Following clear fell the salts locked in the soil profile are released and flushed to the water table where they are transported as a concentrated slug to the nearest recharge point, potentially a wetland.

In providing for the allocation, as with other extractive activities, some broad generalisations have been made as it is impractical to physically measure the consumption per hectare. Harvey, D. (2009) presents a detailed summary of how the allocations for forestry across the LLC PWA have been derived. This work is also summarised in the Draft WAP (2013).

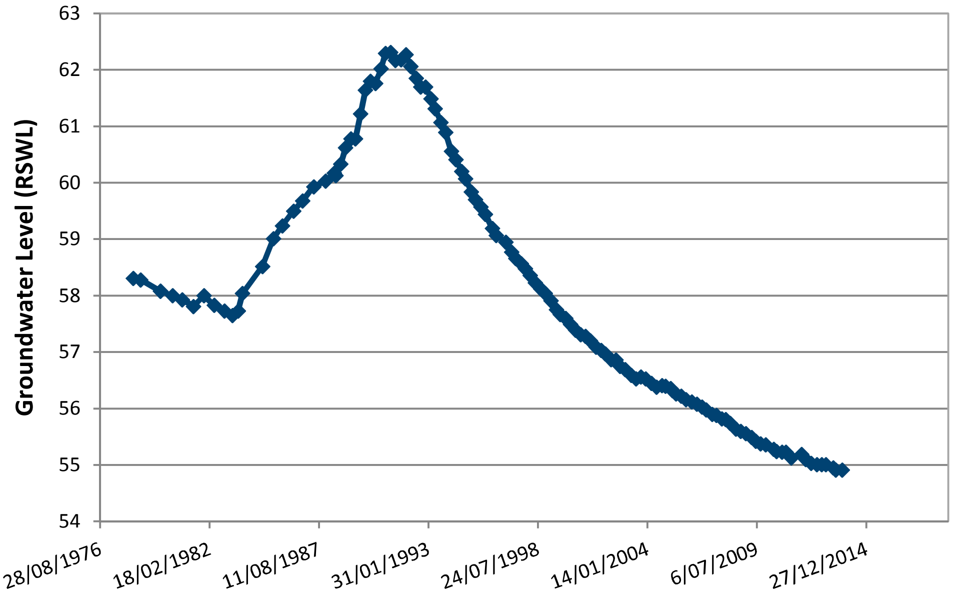


Figure 2: Water level record for Observation well NAN19 1978 to 2013

The new WAP adopted in November 2013 provides allocations for commercial forests but forests that fall within the definition of farm forestry in this plan are excluded from the designation under 76(9)(b) (so as to exclude them from the operation of Part 5A Division 2 of Chapter 7). Therefore the consultant's understanding is that farm forestry provided it meets the strict definition criteria[1] is not required to have an assigned allocation.

The ability to plant 20 ha of forest without the need to have an allocation has significant future ramifications. For example if 4 x 20 ha allotments were planted in the corners of four properties the total area planted is 80 ha. This is a sizable footprint and will lead to the same declines in groundwater levels being experienced in the MAs of Coles, Short and Zone 2A. Small subdivisions are also economically restricted to farm forestry.

With a reduction in available plantation size there is concern that fertilizers and growth accelerators may be used to improve forest productivity per hectare. In this case there is concern that in the longer term this will lead to greater water use especially on the smaller allotments of 20 ha or 10% of the allotment size. Where there is no allocation required for this activity the resultant groundwater impacts will require irrigators to once again suffer a reduction in their licence.

Investigations and long-term monitoring have shown that a concentration of forestry will have an impact on groundwater levels, salinity and through flow. There is no supporting evidence to suggest that concentrations of 20 ha, 10 ha or even 5 ha will

[1] **"Farm Forestry"** means, for the purposes of the Plan, commercial forest where the net planted area does not exceed, or will not exceed 10 per cent of the total area of the land described in a Certificate of Title or Crown Lease, or 20 hectares per Certificate of Title or Crown Lease, whichever is greater and is situated on a farm. For the purposes of the Plan, farm forestry does not include plantings for shade and shelter for stock or crops, natural resources management including soil and water protection, habitat conservation, landscape and amenity values.

not have similar impacts. Therefore, to implement a policy that allows 20 ha of forestry to be planted without an allocation is inconsistent with the objectives of the plan.

Allowing forestry to be planted within 20 m (at the discretion of the Minister) of a surface water body is also inconsistent with the objectives of the plan. Forestry is the single biggest threat to ecosystem health and function because it competes directly for the same water required to support groundwater dependent ecosystems (GDE) function. This issue is discussed further in Section 4.

The state water plan also adopts the position that maximum water use should be used to estimate the amount of water used by plantation forests over the life cycle of the forest.

Use of the maximum water use of a plantation forest to estimate the water used over a life cycle is considered more appropriate. This is because tree growth is inevitable once the plantation is established and water resource planning is aimed at ensuring water security at times of maximum water use. Other uses of water, such as irrigation, farm dams and environmental requirements do not use their maximum entitlement every year, with some variability in use from one year to another, below the maximum allowed. Thus the situation that use in some years may be below the level of entitlement required is not unique to plantations. Consistent with the principles of water planning, maximum water use of the should be used as the most appropriate basis for policy and planning.

The LLC WAP has adopted maximum water use to determine the extractive demand however it only applies to plantations established after 2004.

3.2.3 Allocations to other users

Ecosystems dependent upon underground water become adapted to a particular quantity and quality of underground water and to receiving it in a particular annual and interannual pattern. Changes in the quality or availability of underground water will affect ecosystems and can reduce an ecosystems size or reduce its biodiversity values (Draft LLC WAP, 2013).

In the absence of actual numbers a nominal 10% of the mean annual vertical recharge to each management area (assuming dryland agriculture) has been set aside for environmental water requirements, including maintenance of GDEs and a component of lateral groundwater through flow to mitigate possible adverse salinity impacts.

4 Discussion

4.1 Groundwater State and Condition

Work completed by Brown, et al. (2006), Martin, et al. (2006) and the groundwater review concerning the state and condition of the resource DFW (2011) all identify the areas of Coles, Short, Riddoch and Zone 2A to have declining groundwater levels that exceeded the trigger levels identified in the then current WAP. In general most of these MAs had 50% or more of the area covered by Plantation Forestry. The Current WAP, adopted November 2013, also identifies the concentration of Plantation Forestry in these MAs as a primary cause of the declining groundwater levels through interception of recharge and the extraction of groundwater.

In general the groundwater trends outside of the heavily forested MAs have been declining in response to below average rainfall (drought conditions) experienced over the past decade DFW (2011)[2].

The latest state and condition report DEWNR, (2012) shows groundwater levels across most MAs in the LLC PWA are in fact rising. This is because the monitoring data has only been assessed for the period 2011 to 2012. This is inconsistent with the trigger levels adopted in the WAP (a change over a minimum of three years) or work done by previous investigators, Brown, et al. (2006) and Martin, et al. (2006) that used periods to determine trends consistent with the WAP and also longer terms.

In general salinity levels in the MAs of Coles, Short, Riddoch and Zone 2A are generally stable Martin, et al. (2006); Brown, et al. (2006); DFW (2011) and DEWNR (2012). This is believed to be because the salt is locked in the soil profile. With no vertical recharge under forested areas the accumulated salts are not being flushed to the water table. In areas where salinity has been increasing investigators have generally concluded the primary cause to be return irrigation flows or flushing of salts from the soil profile in response to recharge events. This latter response is especially prevalent in MAs where drip irrigation is predominantly used.

The current WAP plan for the LLC PWA identifies that, typically, salinity increases in the groundwater once clear felling has occurred. This observation is supported by the results of monitoring.

4.2 Ecosystem Function

Considerable work has been done to quantify the needs of GDEs across the South East over the past decade. Whilst actual volumes required to sustain ecological function have been unable to be determined, a greater understanding concerning seasonal fluctuations over which wetlands and other GDEs can tolerate has been gained. Similarly, a greater understanding has been developed concerning salinity ranges over which GDEs can maintain their ecological function. The WAP, November 2013, presents a detailed summary of the work carried out over the past decade into wetland systems across the LLC PWA.

---

[2] Refer to the downward trend in the cumulative deviation from the mean annual rainfall presented in DFW (2011), Brown *et. al.* (2006) and Martin *et. al.* (2006).

However, the WAP falls short in identifying that forestry presents the single biggest threat to wetland function because of the long-term presence of forestry in a particular location. Forestry intercepts recharge and extracts groundwater from the point of canopy closure to clear felling continuously for a period of between nine (hardwoods) and up to 35 years (softwoods).

Forestry is a direct competitor for the same water, i.e. shallow groundwater, required to support wetlands (see Figure 3). Monitoring results clearly show the decline in groundwater levels under plantation forest. Levels have been lowered by 2 m or more over the past 10 years. A secondary impact is that plantation forestry, because of its large foot print, intercepts any through flow.

Unlike the impacts of irrigation, which is seasonal, the declines in groundwater under plantation forestry is long term; nine to 12 years for hardwood plantations and up to 35 years for softwood plantations. There is only a short period of between five and seven years until canopy closure occurs and the whole of cycle reduced recharge and groundwater extraction by forestry commences again.

Additionally, the period where recharge can occur, after clear felling, presents a further risk to any nearby wetlands. Salts which have accumulated in the soil profile are flushed to the groundwater system and can potentially be transported towards a wetland thereby creating loss of biodiversity as a result of increased salinity.

For the identified significant wetland systems, setback distances of greater than 1500 m have been assigned to prevent forestry encroachment and thus potential detrimental impacts.

However, of greater concern is the allowance for new plantings of forestry and farm forestry to potentially encroach to within 20 m of wetlands or other surface water bodies in the November 2013 adopted WAP. Whilst this is at the discretion of the Minister the long-term presence of forestry, either at the plantation or farm forestry scale, if allowed to be planted in such close proximity to the wetlands present a real threat to biological diversity. Additionally, even if planted in farm forestry lots of 20 ha, the aggregated impact will be a decline in groundwater levels, interception of recharge and through flow, and when felled, transport of increased salt loads to the groundwater table.

The aggregated impacts of forestry (developed in 20 ha allotments) over time appear to have been understated. The allowance of 20 ha allotments (with no supporting science to determine if this size will not have a detrimental impact) without holding a water allocation is inconsistent with the overall objectives of the WAP.

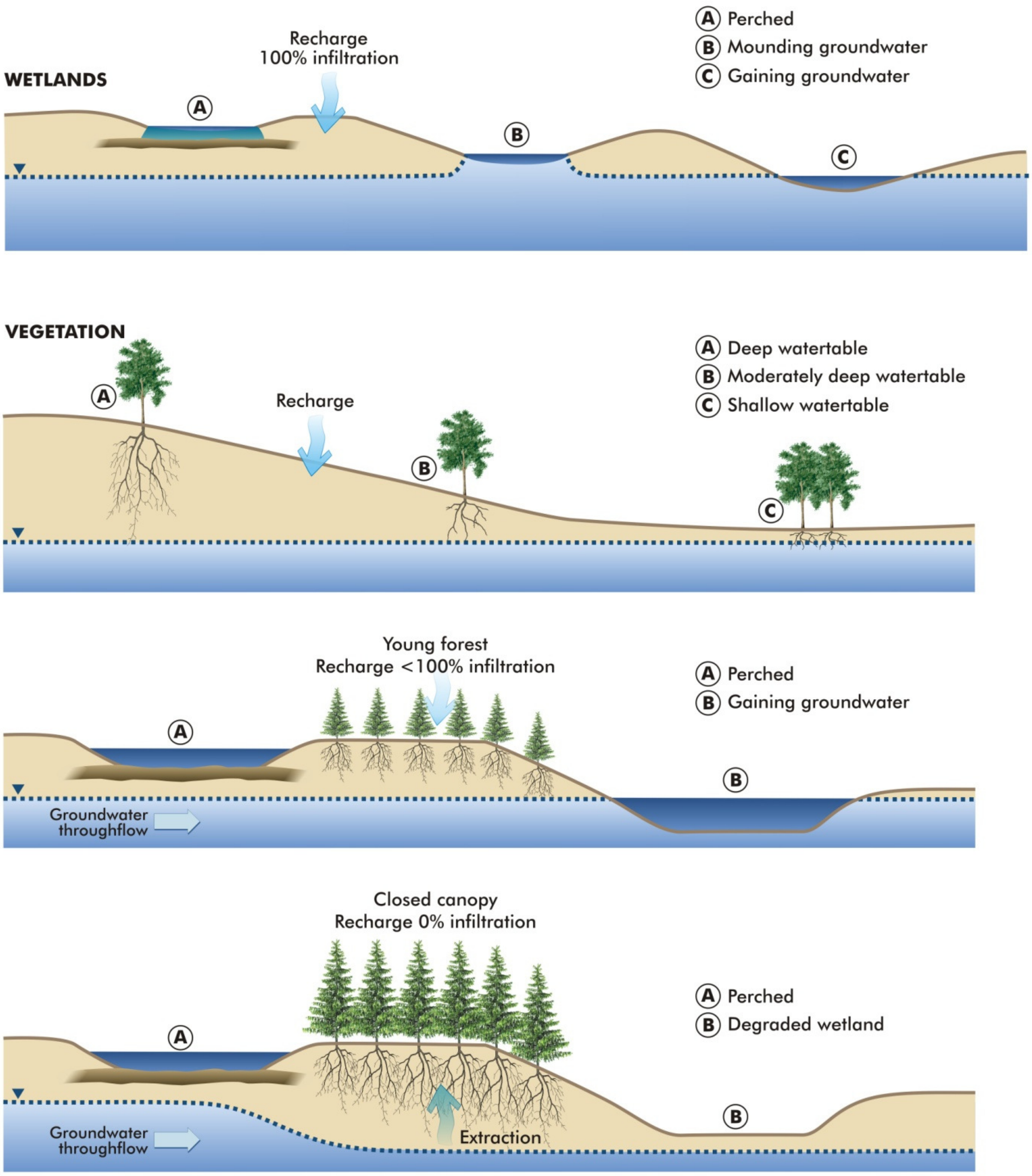


Figure 3: Impacts of Plantation Forestry on Wetlands

4.3 Management Areas and Management Responses

As stated in Section 1 considerable work and consultation has been undertaken over the past decade to update the WAP for the LLC PWA. The groundwater resources are managed by dividing the region into 63 MAs. These MAs are purely administrative boundaries assigned for convenience and based on the extent of the 1:100k map sheets.

Unfortunately, this management approach lends itself to micro management of the resource. The imposition of arbitrary boundaries results in areas quickly becoming over allocated and forces management responses that do not take into consideration the broader resilience of the resource.

As an example, using a risk assessment approach, the current WAP (adopted November 2013) identifies the MAs of Coles, Short and Zone 2A to be very high risk areas with likely significant impacts in the short-term on the environment and users. The concentration in demand, namely forestry (Figure 4), in the MAs of Coles, Short and Zone 2A plus Myora, and Zone 3A is a major factor contributing to the stress on the resource (declining groundwater levels) and over allocation.

The total water account deficit in the Coles and Short MAs is approximately 50,000 ML/yr. The surrounding MAs of Joyce, Spence, Killanoolla, Monbulla, Grey, Riddoch, Mount Muirhead, Kennion, and Fox have a collective water account surplus of approximately 43,500 ML/yr[3].

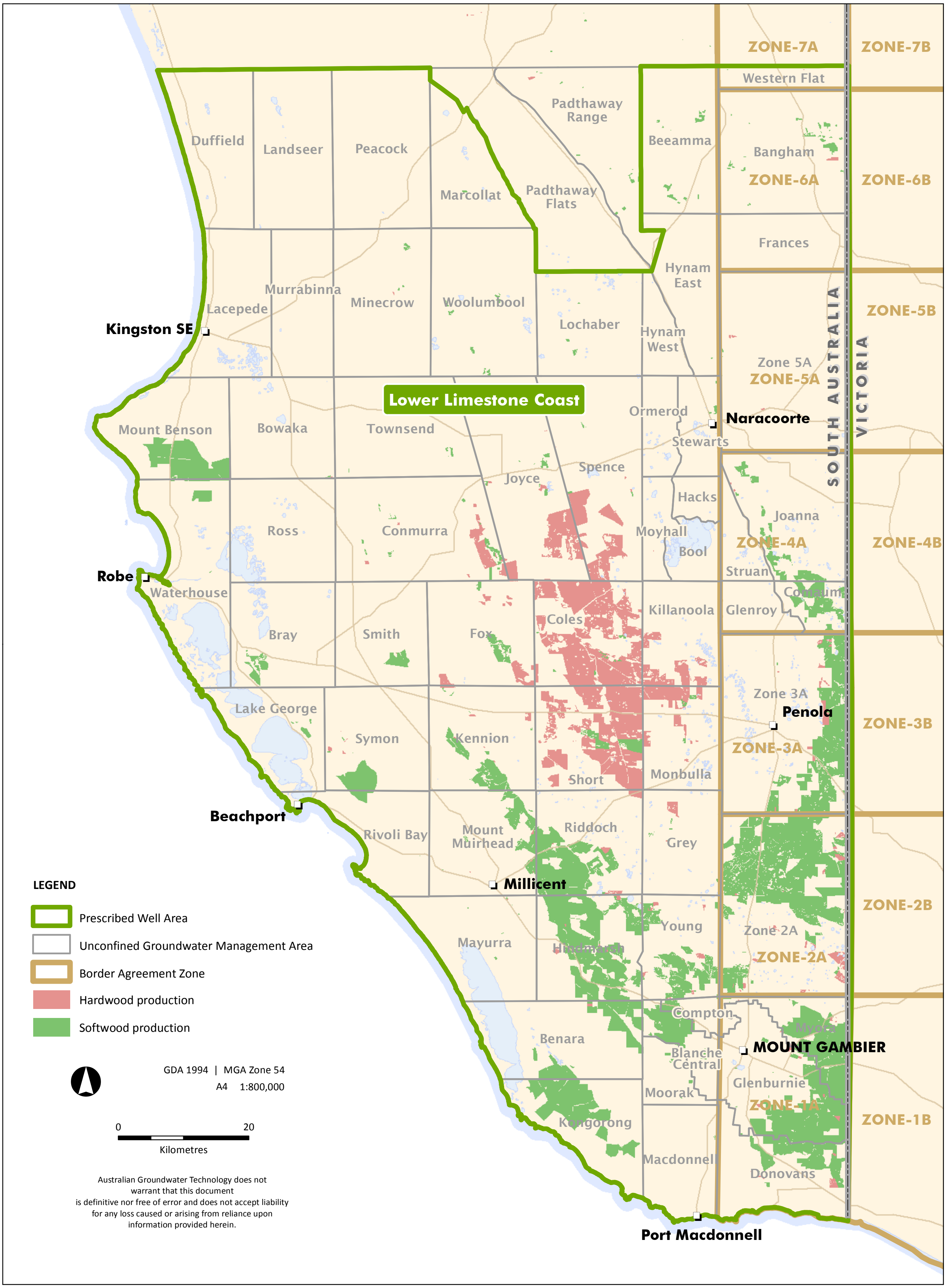
The management response presented in the adopted WAP to the identified very high risk MAs is to cut allocations of non-forestry users in two incremental steps of 8.5% each in 2016 and 2018 (LLC WAP, 3013) in Coles and Short, However in Zone 2A the full cut in non-forestry allocations is a once off reduction of 3% at 1 July 2016. For forestry licensees in Zone 2A, Coles and Short, reductions to excess water are to occur at date of allocation, prior to attaching allocations to forest water licences. Any additional reductions are to occur at clear fell. These target reductions in allocation have been revised downwards since the publication of the draft LLC WAP released in March 2013. It should be noted that in the Draft WAP (March 2013) the proposed reductions in allocations to non forestry users were 25%.

This is an unequitable distribution of the reduction in allocations. Whilst forestry allocations are reduced at the date of allocation by virtue of the crop grown, the impacts to the groundwater resource still accrue until the forest is clear felled.

It appears that this approach of excessive reductions has a risk of overshooting the target meaning that forestry users and non-forestry users may be undeservedly restricted. For equitability, the party with the single biggest impact, because of the greater concentration in demand, should effectively have to take a larger reduction pro rata than users with lower impact. Furthermore, as discussed in Section 3.2.2 forestry has achieved an additional 10% in allocations because the environmental component has not been deducted.

An alternative approach would be to cut forestry allocations by 8.5% and until the equivalent area has been clear felled, no further plantings would be permissible within the MA. Replacement forestry plantings, subject to land availability, could be allowed in adjoining MAs that have a Water Account Surplus. Once the target clear felled area has been achieved, the response of the aquifer system over the ensuing two to three years should be monitored. If groundwater levels continue to decline then all users should take a reduction of 5% of their allocation.

[3] Figures calculated from Table 1 in the LLC WAP.
Note; the MAs of Killanoola and Fox have zero water account surplus.



Australian Groundwater Technologies AGT

Figure 4 | Lower Limestone Coast PWA – Forestry Areas

December, 2013 | P:\(PAN)_Potatoes_South_Australia\Projects\1316-13-PAN_Mallee_and_LLC_PWA_Review\GIS\Maps\final\llc-forest areas.mxd

It should be noted that not all available water has been allocated and not all allocations are extracted. The volume of total available recharge, not extracted, on a regional basis each year currently exceeds 10% (WAP, 2013). Therefore there is capacity to redistribute allocations.

Table 2: Total recharge compared to allocation and total extraction in the Lower Limestone Coast Prescribed Wells Area (Unconfined Aquifer) Source – *Lower Limestone Coast PWA Water Allocation Plan 2013*

Lower Limestone Coast Prescribed Wells Area						
Total annual average vertical recharge (ML/yr)	Total allocation + unlicensed requirements* (ML/yr)	Percentage of recharge not allocated (%)	Total estimated extraction 2009/2010 (ML/yr)	Percentage of recharge not extracted in 2009/2010 (%)	Total estimated extraction 2010/2011 (Ml/yr)	Percentage of recharge not extracted in 2010/2011 (%)
1,295,166	976,582	24.6	508,819	60.7	567,472	56.2

Note: * Includes allocations for irrigation (except volumes assumed to return to the aquifer through deep drainage), recreation, industry, aquaculture and public water supply and volumes to be allocated to commercial forestry, plus stock and domestic and farm forestry requirements.

The Coles and Short MAs could be amalgamated with the adjoining MAs and managed collectively because they are using the same aquifer with the same hydraulic properties, have similar depth to water, similar soil profiles and similar vertical recharge rates. The collective deficit would be approximately 5,000 ML/yr. Amalgamation of management areas has been used in the Mallee PWA (Zones 9A, 10A and 11A) and is also being considered as part of the strategy to reduce the apparent total over allocation for the Central and Northern Adelaide Plains PWAs.

A further example is the MAs of Frances, Hynam East, Myora, Zone 3A and Zone 5A which are identified to be high risk areas under the risk assessment approach applied to the TLA. The MAs of Hynam East, Frances and Zone 5A are within the Naracoorte Ranges and the depth to groundwater is some 15 to 20 m below ground surface. Using age dating, Brown, et al. (2006) have identified the vertical recharge may take 10 to 15 years to percolate to the water table. Therefore, the response in groundwater levels to recharge events in these MAs will be significantly lagging the remainder of the South East. The risk assessment approach seems to ignore this subtlety.

There are opportunities to amalgamate the MAs into a larger areas based on good science to enable more efficient and effective use of the groundwater resources, without changing the total allocation volume. Such an administrative measure would reduce the imperative to make cuts to allocations that may economically disadvantage users.

Groundwater in the MAs of Myora and Zone 3A are considered to be influenced in part by plantation forestry which is concentrated along the border (Figure 3). The forestry in this location is likely to be intercepting through flow and coupled with irrigation, stresses on the resource may be emerging. Amalgamating the region into larger management units would reduce the need to reduce allocations.

Broader regional management areas brings in to play those areas that are under allocated and thus spreads the allocation further across the region Those areas where groundwater conditions are exceeding the adopted trigger levels can be managed as they are in all other PWAs through the transfer process.

4.4 Options for Management of the TLA

It should be noted that the risk management approach to assessing impacts is skewed toward the adoption of a management response to areas of high or very high risk. The response outlined in the plan immediately identifies reductions as the solution to achieve the desired TML for the very high and high risk MAs. It is unclear if any other management approaches have been considered.

The primary impacts on resource condition within the LLC PWA are the result of a concentration of demand by one particular industry within three or four MAs. The TLA covers the whole region although it has differing hydrogeological characteristics from area to area and recharge rates are also quite different across the PWA. The micro management approach of arbitrarily assigning small scale MAs means limited flexibility in response to resource condition stresses.

Other management strategies that could be adopted include:

- Amalgamating MAs to form larger groundwater management units based on more rigorous hydrogeological characteristics.
- Distributing the concentrated demand more uniformly across the LLC PWA by reserving some of the unused allocation in various surrounding MAs. On clear felling in the stressed areas, forestry would be required to surrender the allocation in that area but it would have first right to take up the available allocation in an adjoining MA which is not stressed.
- Encourage irrigators to target the deeper sub-units (e.g. Camelback Member of the TLA) when replacing new wells. This would reduce pressure on the upper aquifer units which the majority of wetlands are dependent.

Martin, R., 1997 (Mines and Energy unpublished) undertook a detailed review of the Hydrostratigraphy of the TLA and TCSA and identified multiple sub-aquifer units. Over time, this work has been built upon and supports irrigation extraction from deeper sub aquifer units (Hill and Mustafa, (DWLBC, 2004 unpublished) Harrington, N., et al. (DWLBC, 2008 unpublished) and Lawson, et al. (DWLBC, 2009 unpublished)).

5 Conclusions and Recommendations

5.1 Conclusions

- Irrigators from the potato industry with extensive holdings within the LLC PWA region have reviewed the draft WAP and consider that equity of access to water has not been achieved across all users. In particular, in Management Areas (MAs) where reductions may be required because the resource is over allocated, it benefits forestry due to the manner in which allocations have been assigned.

- Of further concern to irrigators is the provision for 20 ha allotments of farm forestry without the need to obtain an allocation that may, over time, lead to a concentration of forestry. This may result in the same impacts to groundwater levels as are occurring presently in the MAs of Coles and Short where at least 50% of the MA is covered by forestry.

- There is considerable uncertainty around the origins of the 20 ha farm forestry allotment size. The aggregated impacts of forestry (developed in 20 ha allotments) has not been rigorously assessed and there is no supporting science to determine if this size will not have a detrimental impact over time. Research has shown forestry to be a water affecting activity in the South East and the allowance of further development even in small allotments without a water allocation is inconsistent with the overall objectives of the LLC WAP.

- The current WAP for the LLC PWA, adopted by the Minister for Sustainability, Environment and Conservation and Minister of Water and the River Murray on 26 November 2013, was developed with clear objectives designed to provide flexibility and equity of access to water in order to sustain the ongoing economic, social and environmental systems that depend on that water.

- Considerable effort has expended in the development of the WAP and the development of a clear and transparent process of converting the previous area based irrigation equivalents into a volumetric allocation for proper resource management accounting purposes. Irrigation practices, peculiar to the various industry sectors, have been taken into consideration and concessions such as, watering to manage soil temperature or to mitigate the effects of frost, have been included where practical in the assigned allocations. Provisions have also been allowed for delivery supplements and bridging volumes to allow irrigators to adjust to their new allocations.

- Plantation forestry has been identified as a significant water affecting activity and a similar consultation process has been undertaken with the forestry industry to accept that plantation forestry impacts on the quantity and quality of the available groundwater resources within the region. An agreed process was developed assigning a volumetric allocation to forestry to enabling better accounting and therefore resource management.

- The Statewide policy that requires interception and runoff for all types of forestry to be set at 85% has not been adopted for the LLC WAP. Softwood has an interception efficiency of 83% and softwoods 78%. The WAP was prepared after the release of the Statewide policy so it is unclear why this figure has not been adopted and applied to the forestry allocations.
- The TLA is made up of 61 MAs based on arbitrary boundaries selected for administrative convenience. The MA boundaries are for the most part aligned with the extent of the map 100 sheets and have not been defined based on physical aquifer, soil characteristics or other physiological features. As a consequence, management of the resource at a micro scale will inevitably mean that there are MAs that are over or under allocated.
- The TLA as a whole is not over allocated and in over 70% of MAs there is in fact a Water Account Surplus. Furthermore, not all allocations are extracted; the volume of total available recharge not extracted on a regional basis each year currently exceeds 10% (WAP 2013).
- However, in two or three MAs, because of the concentration of demand (notably plantation forestry), the resource is significantly over allocated and the resource condition triggers are being exceeded. The risk management approach adopted, whilst having a slight bias, identifies these plus four other MAs where the risk of the resource exceeding the defined TML in the near future is high to very high.
- The management response to the identified very high risk MAs (Short, Coles and Zone 3A) is to cut allocations of non-forestry users in two incremental steps of 8.5% each in 2016 and 2018 (LLC WAP, 2013). Forestry allocation is reduced at clear fell possibly 10 to 15 years later depending on when the allotment was planted.
- The management response in those MAs that have been identified as high risk is to reducea non-forestry users by at least 25% of the required amount by 1 July 2016 and by 25% every following two years.
- It should be noted that in areas of Frances, Hynam East and Zone 5 the depth to groundwater is approximately 20 m below ground surface. Age dating of the groundwater has shown that recharge may take between 15 and 20 years to percolate to the water table and therefore in these regions responses to recharge events will be lagging almost all other areas across the South East.
- The proposed reductions in allocations provided in the WAP are considered to be an unequitable distribution. Non- forestry users are required to make adjustments almost immediately, yet the activity which is reported to be having the most significant impact enjoys the benefit of not having to make cuts until some considerable time in the future. Areas that are clear felled in the periods up to 2016 and also 2018 should remain unplanted until forestry has also achieved an 8.5% reduction in allocated volume.
- The TLA is laterally extensive across the whole of the LLC PWA; however, the current MAs have been adopted simply for administrative convenience. As a

consequence applying a volumetric allocation is inevitably going to lead to MAs which, due to a concentration of demand, will be significantly over allocated.

- The risk assessment approach requires a management response in these over allocated MAs but it does not take into consideration the robustness of the resource as a whole or that in neighbouring MAs where the resource is under allocated.

- For example, collectively the MAs of Coles and Short are over allocated by approximately 50,000 ML/yr; however, the surrounding MAs are under allocated by approximately 45,000 ML/yr.

- An amalgamation of the MAs with no change to the total volume available effectively address the over allocation. As with other PWAs the pressure on the resource (declining groundwater levels) associated with the concentration in demand could be alleviated through the management of transfers.

- The resource is resilient and extensive but management at the micro scale present challenges in the form of managing available allocations and inconsistencies in the manner in which allocations are set within and between the various MAs. Managing the resource over a larger area with boundaries defined by using good science provides significantly more flexibility in resource allocation and management and lead to better utilisation of the resource.

5.2 Recommendations

The following recommendations are made to assist in addressing the inconsistencies in the water allocation plan for the Lower Limestone Coast Prescribed Wells Area.

- The Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area should be completely reviewed due to the inconsistencies identified in the plan including the twenty hectare farm forestry component that does not require an allocation. Industry considers this to be a significant oversight and potentially environmentally irresponsible given the documented impacts of farm forestry.

- The 20 hectare farm forestry, or 10% of area, should be reviewed and must be required to obtain an allocation. This is imperative to prevent detrimental impacts to the resource accruing over time from the possible cumulative expansion of multiple 20 hectare allotments in any given management area. The risk is that in the future irrigators will be required to take reductions in their allocations to account for the impacts of the farm forestry.

- Greater recognition needs to be acknowledged concerning the impact of forestry on wetlands and the option of a 20 m setback (albeit at the Ministers discretion) of new forestry and farm forestry allotments from wetlands or other water bodies should be reviewed or deleted from the Water Allocation Plan.

- Consideration should be given to amalgamation of management areas based on good science to provide for significantly more flexibility in resource management and better utilisation of the resource.

- Consideration should be given to assessing the capacity of the sub-aquifer units (e.g. Camelback Member) to support irrigation activities rather than forcing cuts to allocation.

- Efforts should be made to spread the plantation forestry footprint over a wider area throughout the south east e.g. if the existing management area is to be maintained then each area should be allowed a maximum percentage cover of plantation forestry type. The percentage cover will differ for different management areas based on native vegetation occurrence, wetland and other significant water bodies, soil type and depth to groundwater.

- If other deeper sub-aquifer units can sustainably support irrigation non-forestry users should be encouraged, when replacing an existing or adding a new well on their property, to target the deeper sub-aquifer units. This may mitigate the need for any cuts to non-forestry allocations by distributing the demand to a deeper aquifer unit.

- The risk assessment approach should be incorporated and incorporate hydrogeological parameters such as depth to groundwater and the preceding climate patterns. In its present form it appears to be biased toward allocated volumes and aquifer response.

- Consideration should be given to ensuring that in the management areas of Coles, Short and Zone 2A that once an area has been clear felled new forestry plantings should not be allowed until the 8.5% reduction in forestry allocation has been achieved. This would be equitable with the cuts that other non-forestry users are required to make.

- Monitoring should occur over a subsequent two to three year period following the time that the clear felling has been achieved to assess the resource response before instituting any further reductions. There is significant risk that the present approach outlined in the Water Allocation Plan will overshoot the management targets meaning that non-forestry users have had their allocations unjustifiably reduced.

- Adopt the Statewide policy for recharge interception of 85% for the softwoods and hardwood plantations across the Lower Limestone Coast.

- The resource is resilient and extensive but management at the micro scale will present challenges and inconsistencies. Managing over a larger area with boundaries defined using good science provides significantly more flexibility and would also potentially lead to better utilisation of the resource as a whole.

6 References

Aquaterra Consulting, 2010a. *Modelling forestry effects on groundwater resources in the South East of South Australia*, prepared for the Department of Water, Land and Biodiversity Conservation.

Aquaterra Consulting, 2010b. *Modelled hydrological impacts by plantation forest on groundwater resources in the lower South East. A scenarios report*, prepared for the Department for Water.

Brown, K., Harrington. G., and Lawson, J., 2006. *Review of groundwater resource condition and management principles for the Tertiary Limestone Aquifer in the South East of South Australia.* South Australia. Department of Water, Land and Biodiversity Conservation DWLBC Report 2006/2.

Benyon, RG. and Doody, TM., 2004. '*Water Use by Tree Plantations in South East South Australia.*' CSIRO Forestry and Forest Products Technical Report Number 148. CSIRO Mount Gambier SA.

Benyon, R., Theiveyanathan, T., Doody, T., 2006*. Impacts of Plantations on groundwater in south-eastern Australia*. Australian Journal of Botany 54, 181-192.

Carruthers, R., Latcham, B., and Pudney, S., 2006a. *Volumetric Conversion in the South East of South Australia: Summary of the Conversion Model and Associated Conversion Rates*. DWLBC Report 2006/29, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Construction, Forestry, Mining, Energy Union, 2009. *CFMEU FFPD perspective on water management and forest plantations in South Australia.* Briefing note prepared for the Hon. Jay Weatherill, Minister for Water and the Hon. Paul Caica , Minister for Foods

Department for Water, 2011. *Lower Limestone Coast PWA Groundwater level and salinity status report*.

Department of Environment Water and Natural Resources, 2012. *Lower Limestone Coast PWA Groundwater level and salinity status report*.

Department of Environment Water and Natural Resources, 2013. *Development of the plantation forest threshold in the Lower Limestone Coast Prescribed Wells Area.* DEWNR Technical Note 2013/08 prepared by D Harvey, Science, Monitoring and Knowledge Branch.

Gibbs, M., 2010. '*Rainfall and Recharge' in South East Water Science Review*, Lower Limestone Coast Water Allocation Plan Taskforce, Adelaide, Department for Water, pp 3-1 – 3-35. Government of South Australia 2010, *Water for Good: A plan to secure our water future to 2050.*

Harvey, D., 2009. *Accounting for plantation forest groundwater impacts in the lower South East of South Australia.* DWLBC Report 2009/13, Government of South

Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Harrington, N., Chambers, K., and Lawson, J., 2007. (unpublished) *Primary production to mitigate water quality threats Project Zone 1A Numerical Modelling Study: Conceptual Model Development* DWLBC Report 2008/12, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Adelaide.

Latcham, B., Pudney, S., and Carruthers, R., 2006. *Volumetric Conversion in the South East of South Australia: Calculation of the Delivery Component and Bridging Volume*. DWLBC Report 2006/34, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Latcham, B., Carruthers, R., and Harrington, G., 2007. *A new understanding on the level of development of the unconfined tertiary limestone aquifer in the South East of South Australia.* DWLBC Report 2007/1, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Lawson, J., Mustafa, S., and Wood, C., 2009. (unpublished) *Field investigations into the influence of faulting on the groundwater flow and recharge of the Tertiary Limestone Aquifer, Lower South East, South Australia*. Department of Water, Land and Biodiversity Conservation.

Martin, R., Howieson, P., Nicholson, B., and Vertessy, D., 2006. *Integrated water monitoring review of the South East of South Australia – Phase 2* A report prepared for the South East Natural Resources Management Board by Resource Environmental Management and Ecowise.

Primary Industries and Regions SA, 2013. Limestone Coast Region: *Development potential for agriculture, forestry and premium food and wine from our clean environment.*

Pudney, S., 2006. *Volumetric Conversion in the South East of South Australia: Validating the allocation model*. DWLBC Report 2006/30, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.

Skewes, M., 2006. *Climatic Variability and Volumetric Allocations in the South East.* Irrigated Crop Management Service, Rural Solutions, Government of South Australia.

State Government of South Australia, 2009. *The water resource impacts of plantation forests: A Statewide policy framework*, ISBN 978-1-921528-31-6 Prepared for the Hon. J Weatherill and The Hon P Caica.

South Australian-Victorian Border Groundwaters Review Committee, 2001. *Five Year management Review 1996–2000.* State of Victoria, Department of Natural Resources and Environment, Melbourne.

South Australian-Victorian Border Groundwaters Review Committee, 2013. *Twenty-Eighth Annual Report*. Governments of South Australia and Victoria, Department of Environment, Water and Natural Resources, Adelaide and Department of Natural Resources and Environment, Victoria.

South East Natural Resources Management Board, 2013. *Draft Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area*.

South East Natural Resources Management Board, 2013. *Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area*.

Appendix A Forestry Allocation Calculation

Introduction

The approach for setting Permissible Annual Volume (PAV) for each management area within the South East region of South Australia has not been consistent. Estimates of the PAV have previously considered the impacts of forestry by assigning a recharge rate of zero to forested areas, except in the Border Designated Area where variable rates were adopted for forested areas (Bradley, et al. 1995). Further study has identified significant groundwater impacts arising from plantation forestry developments and these are now considered as groundwater users.

Groundwater users include:

- Forestry impacts;
- Licensed extractions for irrigation;
- Industrial and town water supplies ; and,
- Stock and domestic water use.

While the majority of these users have adequately defined estimates of volume, forestry impacts have been less readily estimated. The following examples are designed as examples of calculations used to determine if a resource is under or over allocated.

Brown, Harrington and Lawson (2006) developed a method for determining forestry impacts on groundwater based on a range of previous studies. This method makes several assumptions:

- Environmental Water Requirements (EWRs) for Groundwater Dependant Ecosystems (GDEs) are set at a nominal 10% of the total vertical recharge;
- There is zero recharge beneath Lakes and Native Vegetation;
- Forestry impacts include recharge debits agreed to be:
    - 83% reduction to recharge beneath softwood plantations (Harvey 2013)
    - 78% reduction to recharge beneath hardwood plantations (Harvey 2013)
- Forestry plantations also extract groundwater. Direct extraction of groundwater by forestry plantations is estimated to be:
    - 1.66 ML/ha/yr for softwood (Harvey 2013); and,
    - 1.82 ML/ha/yr for hardwood (Harvey 2013).
- Stock and domestic use rates based on those presented in Water Allocation Plans (WAPs).

Brown, Harrington and Lawson (2006) present a range of variables used within their calculations to determine whether the Management Area is over allocated or not. These are summarised in Table A-1

Table A-1: Summary table of variables

Variable	Description
R_V	mean annual vertical recharge rate
TAR	Total Available Recharge
A_T	Total land area
A_L	Recharge beneath major lakes (assumed =0)
A_{NV}	Recharge beneath native vegetation (assumed =0)
A_N	Net Area
V_{VR}	Net Volume of recharge
V_E	Environmental allowance
V_{HWU}	Total volume of groundwater used by forests
A_{ST}	Threshold area of forestry for softwood*
A_{HT}	Threshold area of forestry for hardwood *
A_{S7}	Existing area of forestry for softwood (based on land use data)*
A_{H7}	Existing area of forestry for hardwood (based on land use data)*
V_{TA}	Irrigation, industrial and town water allocation (2003-2004)
V_{SD}	Estimate of stock and domestic use
V_{TU}	Total Volume of use

Hundred of Coles

Total Area

A_T = 26,873 ha (Brown, et al. 2006)

Net Area

Net Area (A_N) = Total Area less Lakes (A_L) and Native Veg (A_{NV})

$A_{NV} + A_L$ = 3,514 ha (Brown, et al. 2006)

$A_N = A_T – (A_{NV} + A_L)$

A_N = 26,873 – 3,514 ha

A_N = 23,359 ha

A_N = 233,590,000 m^2

Recharge

R_V = Adopted Recharge Rate

R_V = 120 mm/yr (Brown, et al. 2006)

R_V = 0.12 m/yr

V_{VR} = Net Recharge Volume

$V_{VR} = A_N \times R_v$

V_{VR} = 233,590,000 x 0.12

V_{VR} =28,030,800 m^3/yr

V_{VR} = 28,031 ML/yr

Environmental Allowance

V_E = Environmental allowance

$V_E = V_{VR} \times 0.1$

V_{VR} = 28,031 x 0.1

V_E = 2,803

Total Available Recharge

TAR = Total Available Recharge

TAR = V_{VR} - V_E

TAR = 28,031 – 2,803

TAR = 25,228 ML/yr

PAV = Existing Permissible Annual Volume

PAV = 23,400 ML/yr

Percent difference

Δ%= (TAR-PAV)/PAV x 100

Δ%= (25228-23400)/23400 x 100 %

Δ%= 8%

Total Forestry Recharge Debits

R_V = Recharge rate

R_V = 120 mm/yr (Brown, et al. 2006)

R_V = 0.12 m/yr

Softwood

A_{ST} = Threshold area of forestry for softwood

A_{ST} = 610 ha (Harvey, 2013)

A_{ST} = 6,100,000 m^2

V_{ST} = Total recharge debit under softwood

V_{ST} = A_{ST} x (R_V x 0.83)

V_{ST} = 6,100,000 x (0.12 x 0.83) m^3

V_{ST} = 607,560 m^3

V_{ST} =608 ML

Hardwood

A_{HT} = Threshold area of forestry for hardwood

A_{HT} =13,934 ha (Harvey, 2013)

A_{HT} = 139,340,000 m^2

V_{HT} = Total recharge debit under hardwood

$V_{HT} = A_{HT} \times (R_V \times 0.78)$

V_{HT} =139,340,000 x (0.12 x 0.78) m^3

V_{HT} = 13,042,224 m^3

V_{HT} = 13,042 ML/yr

Total Recharge Debit

$V_{ST} + V_{HT}$ = 608 + 13,042 ML/yr

$V_{ST} + V_{HT}$ = 13,650 ML/yr

Current Forest Water Use

Softwood

A_{S7} = 143 ha (Land Use data, 2008)

$V_{SWU} = A_{S7}$ x 1.66 ML/ha/yr

V_{SWU} = 143 x 1.66 ML/yr

V_{SWU} = 237 ML/yr

Hardwood

A_{H7} = 14194 ha (Land Use data, 2008)

$V_{HWU} = A_{H7} \times 1.82$

V_{HWU} = 14,194 x 1.82 ML/yr

V_{HWU} = 25,833 ML/yr

Current Forest Water Use

V_{SWU} + V_{HWU} = Current Forest Water Use

V_{SWU} + V_{HWU} = 237 + 25,833

V_{SWU} + V_{HWU} = 26,070 ML/yr

V_{TA} = Irrigation, industrial and town water allocation (2003–2004)

V_{TA} = 6,276 ML/yr (Brown, et al. 2006)

V_{SD} = Estimate of stock and domestic use

V_{SD} = 222 ML/yr (Brown, et al. 2006)

Total Volume of Use

V_{TU} = Total Volume of use

V_{TU} = (V_{ST} + V_{HT}) + (V_{SWU} + V_{HWU}) + V_{TA} + V_{SD}

V_{TU} = 13,650 + 26,070+ 6,276 + 222 ML/yr

V_{TU} = 46,218 ML/yr

Total Available Recharge

TAR = 25,228 ML/yr

Total Use

V_{TU} = 46,218 ML/yr

ΔV = TAR – V_{TU}

ΔV = 25,228 – 46,218 ML

ΔV = -20,990 ML

ΔV as percent of TAR

ΔV = -20,990 ML

TAR = 25,228 ML/yr

$\Delta V\%$ = -20,990 / 25,228 x 100 %

$\Delta V\%$ = -83% (Over allocated)

Hundred of Short

Total Area

A_T = 25,986 ha (Brown, et al. 2006)

Net Area

Net Area (A_N) = Area less Lakes (A_L) and Native Veg (A_{NV})

$A_{NV} + A_L$ = 3,321 ha (Brown, et al. 2006)

$A_N = A_T – (A_{NV} + A_L)$

A_N = 25,986 – 3,321

A_N = 22,665 ha

A_N = 226,650,000 m^2

Recharge

R_V = Adopted Recharge Rate

R_V = 150 mm/yr (Brown, et al. 2006)

R_V = 0.15 m/yr

V_{VR} = Net Recharge Volume

$V_{VR} = A_N \times R_v$

V_{VR} = 226,650,000 x 0.15

V_{VR} =33,997,500 m^3/yr

V_{VR} = 33,997 ML/yr

Environmental Allowance

V_E = Environmental allowance

$V_E = V_{VR} \times 0.1$

V_{VR} = 33,997 x 0.1

V_E = 3,400

Total Available Recharge

TAR = Total Available Recharge

TAR = $V_{VR} – V_E$

TAR = 33,997 – 3,400

TAR = 30,597 ML/yr

PAV = Existing Permissible Annual Volume

PAV = 21,700 ML/yr

Percent difference

Δ%= (TAR – PAV)/PAV

Δ%= (30,597 – 21,700)/21,700

Δ%= 41%

Total Forestry Recharge Debits

R_V = Recharge rate

R_V = 150 mm/yr (Brown, et al. 2006)

R_V = 0.15 m/yr

Softwood

A_{ST} = Threshold area of forestry for softwood

A_{ST} = 627 ha (Harvey, 2013)

A_{ST} = 6,270,000 m^2

V_{ST} = Total recharge debit under softwood

$V_{ST} = A_{ST} \times (R_V \times 0.83)$

V_{ST} = 6,270,000 x (0.15 x 0.83) m^3

V_{ST} = 780,615 m^3

V_{ST} =781 ML

Hardwood

A_{HT} = Threshold area of forestry for hardwood

A_{HT} =11,479 ha (Harvey, 2013)

A_{HT} = 114,790,000 m^2

V_{HT} = Total recharge debit under hardwood

$V_{HT} = A_{HT} \times (R_V \times 0.78)$

V_{HT} =114,790,000 x (0.15 x 0.78) m^3

V_{HT} = 13,430,430 m^3

V_{HT} = 13,430 ML/yr

Total Recharge Debit

$V_{ST} + V_{HT}$ = 781 + 13430 ML/yr

$V_{ST} + V_{HT}$ = 14,211 ML/yr

Current Forest Water Use

Softwood

A_{S7} = 1,008 ha (Land Use, 2008)

$V_{SWU} = A_{S7}$ x 1.66 ML/ha/yr

V_{SWU} = 1,008 x 1.66 ML/yr

V_{SWU} = 1,673 ML/yr

Hardwood

A_{H7} = 11,957 ha (Land Use, 2008)

$V_{HWU} = A_{H7}$ x 1.82 ML/ha/yr

V_{HWU} = 11,957 x 1.82 ML/yr

V_{HWU} = 21,762 ML/yr

Current Forest Water Use

$V_{SWU} + V_{HWU}$ = Current Forest Water Use

$V_{SWU} + V_{HWU} = 1,673 + 21,762$

$V_{SWU} + V_{HWU} = 23,435$

V_{TA} = Irrigation, industrial and town water allocation (2003–2004)

V_{TA} = 8,633 ML/yr (Brown, et al. 2006)

V_{SD} = Estimate of stock and domestic use

V_{SD} = 245 ML/yr (Brown, et al. 2006)

Total Volume of Use

V_{TU} = Total Volume of use

$V_{TU} = (V_{ST} + V_{HT}) + (V_{SWU} + V_{HWU}) + V_{TA} + V_{SD}$

V_{TU} = 14,211 + 23,435 + 8,633 + 245 ML/yr

V_{TU} = 46,524 ML/yr

Total Available Recharge

TAR = 30,597 ML/yr

Total Use

V_{TU} = 46,524 ML/yr

$\Delta V = TAR – V_{TU}$

ΔV = 30,597 – 46,524 ML

ΔV = -15,927 ML

ΔV as percent of TAR

ΔV = -15,927 ML

TAR = 30,597 ML/yr

ΔV% = -14,425/30,597 x 100 %

ΔV% = -52% (Over allocated)

References

Bradley, J., De Silva, J., Foley, G., Robinson, M and Stadter, F., 1995. *Five year technical review 1990–1995 Border (Groundwater Agreement) Act, 1985.* Dept. Mines & Energy South Australia. Report Book DME 267/85

Brown, K., Harrington, G. and Lawson, J., 2006. *Review of groundwater resource and management principles for the Tertiary Limestone Aquifer in the South East of South Australia.* Resource Allocation Division, Department of Water, Land and Biodiversity Conservation. DWLBC Report # 2006/02.

Harvey, D., 2013. *Development of the plantation forest threshold in the Lower Limestone Coast Prescribed Wells Area*. Science, Monitoring and Knowledge Branch, Department of Environment, Water and Natural Resources. DEWNR Technical Note 2013/08.

arris

agricultural & environmental

Report on Survey of Murray Mallee Potato Growers on Changes in Soil and Crop Management Practices since 2004

Including Items for Consideration for Future R&D Directions

15 January 2014

To: Potatoes South Australia Inc

Version	Date	Author	Reviewed	Issued by
Final	13/01/2014	Dr Adrian Dahlenburg Jim Kelly	Brooke Ryan	Jim Kelly

Created by	Arris Pty Ltd	Bld 11b, Gate 2c Hartley Grove URRBRAE SA 5064 t 08 8313 6706 f 08 8313 6752 ACN 092 739 574
Client	Robbie Davis	
Name of Organisation	Potatoes South Australia Inc	
Name of Project	Report on Survey of Mallee Potato Growers on Changes in Soil and Crop Management Practices Since 2004 Including: Items for consideration for future R&D directions	
Name of Document	Report	
Project Number		
Document Version	Final	
Cover		
Sensitivity	This document and the information, ideas, concepts, methodologies, technologies and other material it contains remain the intellectual property of Arris Pty Ltd. The document is not to be copied without the express permission of at least one of the above parties.	
Disclaimer	This report is presented "as is" without any warrantees or assurances. Whilst all reasonable efforts have been made to ensure the information provided in this review is current and reliable, Arris Pty Ltd does not accept any responsibility for errors or omissions in the contents.	
Document Delivery	Arris Pty Ltd provides this document in either printed format, electronic format or both. Arris considers the printed version to be binding. The electronic format is provided for the client's convenience and Arris Pty Ltd requests that the client ensures the integrity of this electronic information is maintained. Storage of this electronic information should at a minimum comply with the requirements of the Commonwealth Electronic Transactions Act (ETA) 2000. Where an electronic only version is provided to the client, a signed hard copy of this document is can be provided by Arris Pty Ltd if requested by the client.	

Contents

Introduction

In 2012, the South Australian Government adopted a new Water Allocation Plan (WAP) for the Mallee Prescribed Wells Area which translates to a significant reduction in water allocations to some users of underground water in the South Australian Murray Mallee Region. This has the potential to significantly impact on potato production and farm viability in the region. Potatoes South Australia is assisting producers in the region to develop arguments to Government in relation to the potential strategies and time frames to meet the requirements of the 2012 WAP.

Arris was engaged by Potatoes South Australia to undertake a survey of producers in the region to ascertain the extent and impact of changes in land management and irrigation practices over the past 10 years. The survey also attempts to capture any ideas that producers in the region may have on future opportunities for improved irrigation practices, water conservation and improved water use efficiency.

The survey of potato producers in the region was used to achieve an understanding of how the industry has changed in the last 10 years in the areas of:

- Land management
- Crop management
- Water use and management
- Improved farming practices
- Water conservation measures

The survey, together with the review of several relevant recent R&D projects was used to develop suggestions for possible new R&D that could be undertaken for the future benefit of producers in the region.

Executive Summary

- The fresh market potato grown in the Murray Mallee is a unique product in the Australian market and possibly internationally. It is a fresh, predominantly white skin, washed potato that is cold chain handled after processing and has a limited cosmetic shelf life. This potato style is now an established product in the Australian market and quality requirements for growers and processors are market driven. Any changes to production systems that might impact on market quality and appearance need to be carefully considered.
- During the survey discussion it was apparent that the impact of the new WAP on producers in the region is variable. Those drawing water from the Parilla Red zone with limited other options are concerned about the future viability of their enterprises. Future planning for actions either political or technical around regional water issues should ascertain the extent of the local drivers that may facilitate change.
- Changes in management practices and crop production techniques that could be implemented within relatively short timeframes are likely to be making only small percentage gains, but they are likely to give an overall worthwhile benefit. Whole of farm changes are probably not going to be possible as for some seasonal and site situations best practice is already in use. However, in other situations improvements would be possible.
- There are few changes that have occurred in the past 5-10 years to improve water use efficiency. The most significant changes are the introduction of variable rate irrigation (VRI) on pivot irrigators, clay topping and other soil treatments to impact soil moisture retention, more rapid maturing cultivars and more attention to reducing pre-plant and in-ground storage water use.
- The survey highlights a number of areas where R&D may be beneficial. However, research options need close evaluation at the outset in relation to potential outcome implementation issues, particularly cost, service time and maintenance needs as producers in the region are already time and resources poor. Any developments need to make their life easier or less complicated.
- Growers reported in the survey that 65-93% of total water used was for crop production, with in-ground storage being the other major use.
- The current practice of using crop rotation cycles at 5-7 years is an impediment to new system development and there may be some benefit from research into short term (2-4years) continuous cropping systems which would allow for the implementation of new production systems that are financially viable.
- Tools and decision models to assist growers in making better mapping decisions for use with VRI irrigation may be beneficial for increased adoption of the technology and improve performance.
- Chemical soil additives to improve soil wetting characteristics and improve moisture retention are of interest to growers but better evaluation to prove benefits and confirm the best application rates and timing is required.
- Cool-storage is not seen as a viable replacement for in-ground storage on both a product quality and cost basis.

Methodology

A list of survey questions and areas of interest for discussion with growers in the Murray Mallee region was prepared (Appendix 1). Twelve companies and individual growers were identified from the Potatoes South Australia database as having production capacity based in the region and potentially drawing water from the Mallee Prescribed Wells area. All were contacted by phone and seven surveyed / interviewed between December 11, 2013 and January 8, 2014 using the prepared questions and guidelines.

All data and information collected by Arris was taken under an agreement of confidentiality and is only reported in a generalised and summarised form.

Project reports relevant to the topic by other organisations and individuals were reviewed and have been used in this report as collaborative evidence and information.

For this survey the time taken in data collection and the depth of questions means there is likely to be a high degree of variation and error. Any data used in further summary or analysis should first be verified.

Water Use

No growers at the depth of analysis undertaken for this study were able to give a clear indication of their water use efficiency as there are too many variables in the production system that influence overall water requirements for any single crop. Table 1 is a summary of the information obtained; however most was given as approximate and estimated data and would require additional detailed research and analysis to be verified. Time of planting, harvest time and seasonal weather conditions have a significant impact on water use.

Water use rates quoted by the growers or calculated from data provided varied from 5 – 11.5ML/ha with most indicating that for crops grown at a similar time and under similar seasonal conditions the water use over the last 10 years has been relatively stable or increased. However over the same period most also report an increase in yield meaning the water use efficiency (t/ML) may have improved in some instances. Yields ranging from 35 – 55t/ha were reported across the survey for the 2012 production season.

Table 1: Potato crop yields, water use and in-ground storage information (2012).

Grower	Yield (t/ha)	Water Use (ML/ha)	WUE (t/ML)	In-ground Storage
1	35.8	5 (Estimate)	5.2	Up to 4 months
2	48.8	11.5 (Actual mean)	4.2	Up to 3.5 months
3	39.6	-	-	Usually nil – occasionally up to 3 weeks
4	45-55	7-9 (Estimate)	6.3	Minimal – winter months only
5	-	9 (Estimate)	-	Up to 4 months
6	42.6	8-9 (Estimate)	5.0	-
7	Up to 45	-	-	Nil

In-ground storage is used by some of the growers to achieve a continuous market presence and has a variable impact on the amount of water required to bring a crop from planting to harvest. The greatest influence on the volume of water used for in-ground storage is environmental and weather conditions as in-ground storage is generally used to supply the July to October market period. Occasionally in-ground storage can be used at other times to adjust to the market situation but would generally be for less than a month.

The estimate of the proportion of total water use against various activities in the growing cycle varied quite considerably across the growers. Estimates for the actual crop growth (planting to maturity) varied from 65 – 93% of the total water use on the farm. The most significant use apart from crop growth was in-ground storage at 5 - 35% with pre-planting soil preparation and postharvest crop establishment at 2 - 15%.

The variability in volume of water used to keep soil damp and potatoes fresh during in-ground storage is to be expected when taking into account the time the crop is harvested after maturity and seasonal weather variability. Under current production systems and to meet market quality requirements, in-ground storage is considered essential and will continue to be a variable and often significant use of water.

Growers are generally minimising water use for both pre-plant soil preparation and postharvest operations required for soil drift and erosion control.

Crop Rotations

All growers in the region operate on a 5 – 7 year rotation cycle between potato crops. The off years in the cycle are predominantly cereal crops grown with no supplementary irrigation. There are a few instances of onions and/or carrots being included as alternate crops in the rotation cycle.

The long rotation cycle has a significant impact on the feasibility of potentially new and alternate soil and crop management/production systems. Alternate irrigation systems like drip or sub-surface which could potentially provide a saving in water use are not seen as practical or a cost effective techniques where the production site is not irrigated and managed in a similar manner for the 4 or more years between potato crops. Similarly fixed beds and controlled traffic options are not viewed as feasible or advantageous during the cereal cropping years and would in most instances be seen as a hindrance.

Soil Management

Site Preparation:

Some growers are using clay topping under pivot irrigation sites for potatoes to improve soil stability, water retention and crop growth. Clay topping is when heavier clay soils in the low lying areas under the pivot site or from other sites on the farm are laid over the light soil on the top and side of sand hills. Up to 200t/ha of clay is laid over the sand and incorporated into the top 200mm of sand. Some growers have also used the reverse procedure of moving sand onto the heavy soil sites between the sand hills. The value of this treatment will be related to the soil variability and conditions at any particular pivot site and needs to be evaluated against the potential benefits for that site.

This is an expensive exercise but seen by those using the technique as a value for money investment with improvements in water retention benefiting crop growth particularly under hot and dry weather conditions, easier wetting of the sandy soils, and improved water holding capacity. The improved uniformity of water application across the pivot site that can be achieved from this treatment is also a significant benefit impacting both crop productivity and operation costs. Care is needed with this practice to ensure the clay is finely divided before or during incorporation with the sand so that there are no clay clods which can impact on potato quality.

Pre-Planting:

All growers aim to complete soil preparation within 1 - 4 weeks before planting. The pivot site for planting is irrigated with up to the equivalent of 100mm of rainfall before soil preparation is commenced or during preparation. A range of soil preparation techniques are used and this study was not able to determine the benefits or otherwise of any particular method. Best methods are also likely to be related to the individual site soils, previous crops on the site and seasonal weather conditions. Methods used included:

- Deep ripping and rotary hoeing (often only 1 pre-plant pass required);
- Deep ripping and discing 2 or 3 times. Ripper tine spacing impacts the amount of clay clods brought to the surface that have to be dispersed and incorporated; and
- Offset disc and tine cultivation and /or rotary hoe, working up to 4 times.

On some sites, deep ripping is used to break-up clay layers and improve drainage as well as bring some clay to the surface for incorporating with the more sandy top soil. Theoretical savings in energy and water use should be achieved with the shortest preparation time and minimal tillage passes over the site.

Planting Systems:

Both two row beds and single row mounding is being used by growers in the region. Those using bed planting believe there is a saving of water achieved and it can be beneficial in reducing irrigation run-off allowing for increased application rates in a single pass of the pivot. Those using the mounded single rows believe there is little if any reduction in water use to be achieved by going to a bed system, particularly if crop growth rapidly covers the inter-row gap. A decision to change to bed systems can also be influenced by the capital costs involved in doing so, as different (or at least modified) planting and harvesting equipment is needed.

Bed growing systems should theoretically reduce water use with the reduced soil / air surface area and there is also potentially less chance of tuber damage / crop stress as a lower volume of soil around the roots of the plants will be dried. Row or bed orientation in relation to slopes and terrain under the pivot could impact on water use, particularly in relation to potential run-off. Divots in inter space can be used to help intercept and manage run-off.

Soil and Tissue Analysis:

There is variable use of soil and tissue sampling as crop production and management tools. While the use of neither of these tools has a direct impact on water application and water use, a healthy growing crop has the maximum potential to utilise the water and nutrients available and hence maximising water use efficiency (t/ML). Most nutrients after planting and early crop establishment are applied through the irrigation system either in a programmed approach or in response to tissue analysis results.

The relatively low use of pre-plant soil analysis is understandable when viewed in light of the potato production cycle in the region with 4 or more years of low (relatively) nutrient input cereal production between each potato crop. With the light sandy soil of the region having high leaching and poor nutrient retention capacity, it is not unreasonable to assume that the vast majority of the nutrients required to grow the potato crop will need to be provided immediately before and within the growing season. Within season tissue testing to optimise nutrient profiles during crop growth is likely to be a more valuable investment of limited resources, particularly if linked with site mapping and variable output nutrient applications.

Controlled Traffic:

For soil preparation, planting and field operations during the growing season most growers are using GPS guided machinery and controlled traffic practices for machinery used under the pivot. Any controlled traffic lanes using during the potato crop phase are not maintained after the crop is harvested and only re-established on different co-ordinates when the next potato crop is planted. This would seem to be appropriate use of this technology for this production system and no variations can be imagined that might improve water use efficiency.

Yield Mapping:

Any yield mapping done by growers is fairly crude in nature and limited in value as a crop management tool. The ability of harvesting machinery in use is likely a limiting factor in relation to collecting this data. While the crop production cycle is long with many years of usually cereal cropping between potato crops, there is no reason to believe the variation in crop yield potential across any particular pivot site would not continue to be reflected on a long-term basis. Hence high quality yield mapping has the potential when coupled with appropriately managed resource inputs to improve yields and water use efficiency.

Soil Amendments and Treatments:

All growers are using pre-plant soil preparation practices that will benefit the building of soil organic matter and many have tried a variety of different soil treatments but are generally not sure of, or convinced whether there are any long-term benefits. The latter is particularly true for chemical soil treatments and moisture barriers, as there is little rigorous scientific evidence to support benefit claims, and growers trialling these products do not have the time or resources to obtain conclusive results. However, many are optimistic that in the future there will be significant benefits from chemical soil treatments, but the research is required to establish the degree of benefit and the best ways of using the treatments in the production system.

The use of composts has improved productivity for some growers and continues to be developed by them as a soil treatment.

Between Potato Crops:

The growing of cereal crops using naturally occurring rainfall is standard between season management for the potato pivot sites. The principle concerns for growers in these intervening years are soil erosion / drift control and management of weeds.

Irrigation

Centre Pivot Irrigation:

All growers in the region are using centre pivot irrigation systems for potato production. Centre pivots provide flexibility by allowing them to be moved short distances to new sites each year and permit the 5 - 7 year production cycles currently employed at an acceptable infrastructure cost. They are also efficient irrigation systems to water large areas of row crops like potatoes. Steve Hall from Hall Irrigation at Lameroo has confirmed many of the points made throughout this report in regard to the issues concerning irrigation in the region and other matters of concern to the growers in the region. (See Appendix 2 for a summary of Steve Hall's comments).

Centre pivots are not problem free systems and require constant monitoring and evaluation to ensure high efficiency performance is maintained. Remote telemetry is used by some growers to permit remote monitoring and operation of the pivot. Care in the design of the pivots is essential to ensure they are well matched to the pumps and water supply. They must be adequate to meet the worst case scenario conditions when maximum water delivery is required under very hot and dry conditions.

Recent innovations in pivot irrigation have seen the availability of Variable Rate Irrigation (VRI) where nozzles along the pivot are either shut off or pulsed to achieve variable volume outputs in response to a computerised map of the pivot irrigation area. Existing pivots can be retrofitted with the technology or it is available as an option on new units. Several growers have invested in VRI systems and believe it is a worthwhile investment delivering water applications that are much better matched to soil and crop requirements. The cost of the VRI system is significant and for some growers just adds another layer of complication to their irrigation system. Hence some producers are not convinced of the value of the system and this is more likely to be the case where soil conditions and terrain under any single pivot are not highly variable.

Mapping of the irrigation areas is done using GPS data, manually or automatically collected and can be provided as a user paid service by the pivot suppliers. However, decisions still have to made on where the boundaries of the mapping zones are to be located and on what basis the boundaries should be set. To maximise the benefit of VRI, accurate mapping is essential and this is not easily achieved currently.

Soil Moisture Monitoring:

In 2006-2008 considerable time and financial investment was made by the South Australian Murray-Darling Basin Natural Resources Management Board assessing crop water use in the Mallee. (South Australian Murray-Darling Basin Natural Resources Management Board (2008)). A key component of that project was to assist water users in the Mallee to better understand their water use and introduce them to water monitoring techniques and computerised water use analysis software. This project reported that some grower participants in the project had difficulty with the technology and the data interpretation/collection required to obtain the benefits that the technology offers. However, there was generally a positive attitude towards the value of soil moisture monitoring supporting current practices, and perhaps through ongoing use, growers will achieve a better understanding and be able to correlate with observations currently used in decision making.

This survey indicated there was little current use of soil moisture monitoring equipment and it was not used as a routine irrigation scheduling and application rate tool. The reasons given for the lack of use of this equipment included cost, time required to interrogate and interpret data and the inability of such systems to cope with the variability across any pivot site. Lack of confidence in the system and again the adding of another level of complexity to the production system are probably key factors in low levels of adoption. Many view systems like this as redundant and adding little value as experienced farm managers and operators will, on a near to daily basis, be inspecting the growing crop and can make any necessary adjustment to water application rates.

Irrigation Scheduling:

Experienced managers are employed to undertake crop and soil moisture observations together with weather forecasting to set irrigation scheduling and the amount of water to apply with each pass of the pivot. Evaporation data is also being used by some growers as an additional guide to assist in irrigation scheduling.

Frost Control:

Centre pivots can be used for frost control and have been used for this purpose by some producers, however there are difficulties resulting from inappropriate nozzles, timing of coverage and excess water application. Alternate frost control systems are likely to be more effective and not reliant on limited water resources but they need to be evaluated in terms of infrastructure and operation cost vs potential production / sales loss from frost damage.

Research Needs and Future Directions

Reported here is a combination of items and issues that were raised by the growers during the survey plus literature review information and observations on trends and other possible directions identified by the authors.

Crop Production Systems:

Most growers do not see any alternate cropping systems as being affordable or viable, primarily because production sites are moved after each crop. Hence any systems like drip or sub-surface irrigation and permanent beds have an infrastructure investment that cannot be recovered over a single crop. However, all of this is on the premise that only a single crop in a 4-6 year cycle is possible for productivity and quality reasons. While not explored in this survey, experiences / research into continuous cropping for 3 or 4 crops may be worthwhile to determine if this is a potentially viable cropping system. Recent new developments like commercial soil analysis services for soil borne pathogens may assist in achieving successful outcomes that were not possible in the past. There would be significant cost savings if it were feasible to produce 3 or 4 productive and high quality potato crops on the same site before moving. This potential new opportunity may lead to significant water savings in the preparation of land and through the access to stored soil moisture retained from the previous crop, however, research will be required to assist in assessing risk vs benefits.

Soil Amendments and Treatments:

Most growers believe there are some gains to be made in this area and there are a range of options that might be effective.

Mulches and composts have been tried with one reported 20% yield increase. Incorporation of mulches and composts before planting will improve the organic matter and nutrient content of the soil with benefits in improved water holding and wetting capacity, healthier micro-flora and a nutrient boost in the soil. Raw materials for production, consistency and reliability of performance, seasonal and climatic impacts are all issues that require research and understanding from experience in regular use to achieve consistent outcomes. Soil and crop nutrient analysis will probably also be an important component in maximising the value of any compost type soil treatments.

Chemical treatment to improve soil wetting, moisture holding capacity and to reduce soil surface evaporation have been used by many of the producers using trial materials provided by the manufacturers or agents. Most testing is not undertaken under controlled experimental conditions which leaves most users uncertain if there is a real benefit. Any improved yield may have been associated with a change in any number of other variables which had an influence on crop yield and quality. This will require research to be undertaken with standard experimental design parameters to gain the appropriate level of understanding and provide the necessary information to growers for adoption.

Despite this, there is a belief among some growers that there are potential benefits for them now or in the future as new technologies and chemistries deliver new products. The greatest current difficulty, which growers do not have the time or possibly expertise to tackle, is sorting through the range of products available, determining their potential benefits and understanding how and when one or more of them can be best used in their production system.

Clay topping of sand hills and sand topping of heavier / clay soil sites in potato production areas will bring benefits in production and yield through more uniform soil moisture conditions across the site. One grower reported an average 20% yield increase across a full site after clay topping. Improving the uniformity of water absorption and moisture holding capacity must have benefits for those using centre pivots that are not fitted with VRI systems as water applications can be closer to optimal for a greater percentage of the crop. Moving soil around a site to achieve the changes required is expensive but it is a once-off operation that will have long-term benefits for all crops grown on the treated site.

Site Mapping:

For those growers using VRI pivots, site mapping is an important requirement to get the best from the system. At least one user was pleased with the current mapping service and implementation on the pivot, but others were concerned about mapping accuracy and the best basis for mapping a site. Soil type and moisture holding capacity are obvious choices for mapping boundary decisions, but possibly other factors like canopy cover, yield potential, drainage issues, and nutrient availability could be overlayed to achieve a better outcome. However using this additional data is a complex issue and would require research to develop very specific algorithms for beneficial use in the mapping software. Simplified site mapping would benefit not only VRI users, but would be a valuable tool for those using simpler pivot designs and more traditional irrigation scheduling techniques. The first step in advancing this would be to approach pivot equipment manufacturers or their third party suppliers to ascertain what they potentially might already be developing in this area.

Monitoring and Data Collection / Record Keeping:

Monitoring of crop status and inputs was also highlighted as a key management issue in the SA-MDBNRMB project in 2010 where it was concluded: “The value of on-going monitoring in order to effectively measure and manage the many different in-field variables affecting production and to support the implementation of adaptive management practices can’t be understated” (SA Murray-Darling Basin Natural Resources Management Board (2010)). The technology is now available at relatively low cost to monitor and control irrigation equipment from remote sites. This can provide “peace of mind” operation, an increased level of flexibility in operation and free up time for site managers to undertake other tasks. This same technology can be used with appropriate sensors to collect information on a regular and on-going basis to assist in current and future decision making. Good record keeping is a valuable tool in improving systems and could, through computerised systems, be collected automatically via wireless and mobile communications. Development effort (finances and time) is needed to bring together the platforms (equipment and software / apps) and user interfaces required to make it user friendly and workable in the industry environment.

Crop Management:

While not an easily achieved option for some producers in the region, the use of alternate production regions outside of the Murray Mallee is a viable means of maintaining total production while drawing less water from the limited recourses in the Murray Mallee. There are other regions in South Australia and Australia that have the soil types, climatic conditions and water resources to produce an equivalent quality product. This strategy has also been used by some of the larger producers with various regional properties to reduce in-ground storage requirements through manipulation of production times in the various regions.

Planting to demand is practised as best as possible considering seasonal and climatic conditions can quite significantly impact on the final yield from a particular site. As the maintenance of soil moisture for in-ground storage can be a significant user of water in the production cycle, minimising this time is important.

Optimal growth conditions for the crop are important to achieve tuber size and maturity at the earliest possible time. Hence crop health monitoring (pest, pathogens and nutrition) is also important to ensure crops can be harvested when planned.

Cool-storage vs In-ground Storage:

One of the areas in the production cycle where water could be saved is to eliminate in-ground storage. The current production system for potatoes in the Mallee is unique (at least nationally) in the style and quality of potatoes produced. The demand for the clean fresh white skin washed potato from this region is now highly market driven and no cool-storage system can deliver the same quality to the market. Cool-storage is able to maintain the internal and eating quality but cannot maintain the skin colour and freshness achieved with in-ground storage. The cost of building and running cool-stores plus storage bins is also seen by most growers as a serious impediment to the use of cool-storage.

Cool-storage has been used to fill orders in October in some years when there is an anticipated need for stored potatoes to be used to meet market requirements. In such cases, better quality outturn from the cool-stores is achieved when potatoes are harvested and placed into storage close to the time when they have reached maturity.

The Victorian processing industry has significant experience with the cool storage of potatoes for processing purposes. It needs to be understood that the characteristic requirements of processing and fresh potatoes are significantly different. The processing growers interviewed reported that there was some loss of aesthetics of potatoes relating to the skin and appearance of stored potatoes, a key feature that has made South Australia the leading producer of fresh washed potatoes in Australia (represents 80% of the national fresh washed potato production).

Growers in the Koo Wee Rup region have experienced issues with Potato Cyst Nemetode (PCN) outbreaks which, in the mid 2000-2010, threatened the transport of potatoes from Victoria to South Australia for processing. A protocol was developed with AQIS SA in which the potatoes would be stored and washed (removing cysts) prior to shipment. Further to this, to be able to supply potatoes for extended periods for processing, cool-storage has been used for some time.

The growers advised that cool storage was not without issues:

- Deterioration in the 'look' of the potato (mentioned above), changes in colour and blemishes;
- Storage impacts the integrity of the skin, washing post storage increased skin damage that would impact pack-out rates of fresh potatoes;
- Loss of weight of between 2-5%. Processing growers are compensated for this by the processing company; and
- There is a cost of cool-storage in the order of $45/t, again the growers are compensated. It would be a cost that growers and/or packers would have to absorb in the case of the fresh washed potato industry,.

Interestingly, the processing growers commented that they saw significant barriers to the use of cool-storage for the medium-to-long term storage of un-processed fresh washed potatoes. Their experience highlighted issues that did not necessarily impact the quality of processing potatoes but would be a significant barrier to the use of cool-storage for quality fresh washed potatoes.

Cultivars:

There are some commercially acceptable cultivars available that have shorter growing periods to maturity than more traditional fresh market varieties. The 2010 SA-MDBNRMB project report had a key focus on the role of cultivars in both the management of salinity and reduced growth cycles for potatoes growing in the Murray Mallee (SA Murray-Darling Basin Natural Resources Management Board (2010)). "The project confirmed that differences in salinity tolerances between potato varieties can be significant and therefore must be considered when determining varietal selection at individual planting sites." It was also reported that for the variety Nadine, planting to maturity times as short as 75 days was achieved with an average growing period of 89-99 days. However this is still considerably less than when originally introduced, "Nadine was widely regarded as a 115-125 day variety yet with managed seed maturity at planting the growing season has been reduced".

Industry needs to be encouraged to use short growing period cultivars as much as possible as every day of earlier maturity is a day less water required. Concerns with new cultivars include general industry availability due to Plant Breeders Rights (PBR) restrictions and marketing contracts surrounding all new cultivars. Furthermore, market demand and suitability will drive breeders and new cultivar developers towards cosmetic quality market requirements without consideration for production requirements.

References

SA Murray-Darling Basin Natural Resources Management Board (2010): Managing Salinity for Sustainable Potato Production in the SA Murray Mallee Region. Landcare Australia Report:1.1 Sustainable Salinity Management in the SA Murray Mallee.

South Australian Murray-Darling Basin Natural Resources Management Board (2008): Assessing Crop Water Use in The Mallee. Author:Irrigated Crop Management Service (ICMS), Rural Solutions SA

Appendix 1 : Grower Survey / Interview Question Guidelines

Farm Details

- Name:
- Location(s):

Land Use

ANNUAL CROPPING	2002	2012
Potatoes (Area)	ha	ha
Potatoes (Production)	tonnes	tonnes
Irrigated Crops other than Potatoes	ha	ha
Other Crops	ha	ha

Water Resources

- No of Wells / Bores: 2002 2012
- Prescribed Wells Area Description(s):

Water Use (Total Property)

Total Extracted Volume: 2002 2012

Allocation of Water (by Volume or % of Total)

SECTOR	2002	2012
Brief description of potato cropping rotation and site preparation		
Irrigated crops other than potatoes		
Potato: soil preparation/pre-planting		
Potato: growing the crop		
Potato: in ground storage		
Potato: post-harvest soil applications		
Potato: washing/processing/ cooling		
Other farm uses for water (e.g. livestock, domestic)		

Soil Management / Preparation

- Between Seasons Management
- Pre-planting preparation
- Soil analysis – key decisions based on analysis results
- Moisture conservation practices
- Controlled traffic
- After harvest treatments
- Use of soil amendments

Please comment on changes since 2002.

Irrigation

- Irrigation system(s)
- Water distribution and application efficiency enhancements to equipment
- Soil moisture monitoring systems
- Scheduling decision process
- Equipment testing

Please comment on changes since 2002.

Looking to the Future

What are some of the potential areas of production and management where gains may be made in the future?

- Alternate irrigation systems – drip / sub surface
- Permanent beds - utilising minimum till
- Soil moisture barriers
- Changed crop management – minimum field time
- Drainage water
- Soil management
- Alternate cropping systems
- Soil amendments (poly acrylamide, mulching, etc.)
- Erosion control other than water
- Precision Farming
- Soil moisture monitoring

What research is required to increase Water Use Efficiency in the following?

- Soil Management
- Crop performance and production
- Alternate cropping systems
- Irrigation management and system
- New systems for potato storage

Appendix 2: Hall Irrigation Interview

Mr Steve Hall of Hall Irrigation, Lameroo provided the following insight into potato irrigation practices in the Mallee.

There has been a steady transition and adoption of new technologies to improve irrigation efficiency. He advised that the biggest irrigation related issue facing growers is the cost of fuel/energy for pumping water, which has been the main driver for adoption of new technologies that improve irrigation efficiency and reduce water use.

The main technologies being adopted by farmers to improve irrigation efficiency have been:

- Variable rate irrigators where application of water can be controlled down to a resolution of $1m^2$;
- New pivot sprinklers that have dramatically increased the uniformity of distribution, giving better spread of water and reducing runoff;
- Remote control of irrigators; and
- Remote control of soil moisture monitoring equipment enabling the application and management of irrigation based on demand rather than temporal scheduling.

Other technologies that are being trialled and used include:

- Detailed soil and land mapping: topographical, electromagnetic induction and soil textural classes and horizon depth. This is an essential requirement for the variable rate irrigation technology.
- Dam and dyking is a system of soil management that creates little dams or dykes to retain water where it is applied improving the infiltration efficiency and reducing runoff and flooding of low lying areas.
- A South Australian company, BioCentral Laboratories (www.biocentral-labs.com) has been trailing the use of polymers to improve water holding capacity and soil erosion minimisation.
- Drip irrigation has been assessed but cost of installation and management issues are seen as barriers to adoption. The potential operational savings due to the lower pressure requirements over spray irrigation systems may offset installation costs. The issue of long plant back periods and the management of drip irrigation equipment is seen as a significant barrier.

Mr Hall advised that approximately 30 variable rate irrigators (VRI) have been installed, the early adoption of this technology has been by the larger players. VRI still represent a relatively small proportion of the irrigation systems in the region, however, it is anticipated that this will increase as scheduled equipment replacement is undertaken by producers. Interestingly, he advised that the main driver for adoption of new technologies to-date has been to reduce the cost of fuel and energy.

arris
agricultural &
environmental

Arris Pty Ltd
ABN 91 092 739 574

South Australian Office
The Waite Campus
Bld 11b Gate 2c
Hartley Grove
URRBRAE SA 5064 Australia
Tel +61 8 8313 6706 Fax +61 8 8313 6752

Queensland Office:
44 Wentworth Terrace
ROCKHAMPTON, Qld 7400 Australia
Tel +61 407 268 069 Fax +61 8 8313 6752

info@arris.com.au

www.arris.com.au