Australian Government
Cotton Research and Development Corporation

Annual, Progress and Final Reports

REPORTS

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number:		**CRC37C**
Annual Report:	☐	Due 30-September 2004
Progress Report:	☐	Due 31-January 2004
Final Report:	☒	Due 30-September 2004 (or within 3 months of completion of project)

Project Title: Measuring the Influence of Varying Water Quality on Drainage Through Irrigated Cotton Soils.

Project Commencement Date: 1 July 2001 **Project Completion Date:** 30 June 2004

Research Program: 2 Integrated Natural Resource Management

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Measuring the Influence of Varying Water Quality on Drainage through Irrigated Cotton Soils

CRDC Project number: CRC37C

Completed December 2004

RURAL WATER USE

Queensland

Australian Government
Cotton Research and

Part 3.3 – Final Report

1. Background to the project.

This project was conceived shortly after the finish of the first Rural Water Use Efficiency (RWUEI) initiative. A principal finding of RWUEI was that "the main water loss infield (under irrigated cotton) was from deep drainage" and that "furrow irrigation had not been well monitored or well managed" (USQ media release 13th July 2000). While RWUEI did much to develop practical ways for farmers to improve WUE, it did little to quantify the effects of water quality on deep drainage in relation to soil type or to direct measurement of deep drainage (DD) under irrigated cotton crops.

The current project was devised in the knowledge that increased sodicity and salinity of percolating water will alter the saturated conductivity of many soils, especially sodic soils. Previous lysimeter research and current drainage modelling on the Darling Downs (Qld) has directly measured and predicted leaching fractions of up to 40% under irrigated cotton grown on black cracking clays. These clays can be very sodic at depth, and can be irrigated with water with an Electrical Conductivity (EC) of over 4 dS/m. It was also noticed that small increases in irrigation water salinity had an impact on drainage.

Direct measurement of DD have previously proven difficult and costly. By installing 3 drainage lysimeters (barrell-type lysimeters) on each of three cotton growing farms, this project aimed to quantify the effectiveness of these new, relatively inexpensive, drainage measurement tools.

2. Project objectives and the extent to which these have been achieved.

The project had two principal objectives:

1) To utilise drainage lysimeters to directly measure drainage and correlate responses in column experiments to field response.

- nine drainage lysimeters were installed in a total of 3 cotton fields and data were collected over a period of two cotton seasons.

2) To assess the effect of increasing salinity and sodicity of irrigation water on the deep drainage under various soil types associated with cotton production.

- a glasshouse experiment was conducted to assess the effect on deep drainage of changes in salinity and sodicity levels, waters being applied to intact cores (soil columns) collected from each field site.

Detail the methodology and justify the methodology used.

Three sites were selected, where the barrel lysimeters would be installed and intact cores collected for the glasshouse experiment. Site selection was based on detailed discussions with local growers, agronomists and pedologists to ensure sites selected were representative of the cotton growing soils in the 3 regional areas. Table 1 gives the latitude and longitude of the three sites selected, one at each of:

- Dalby (20 km west of the town); a black cracking clay (Black Vertosol); field length 720 m, skip-row cotton with one row in 3 metres width
- St George (20 km south of the town); a brown cracking clay (Brown Vertosol); field length 532 m, on 1 metre beds
- Goondiwindi (35 km south east of the town, on the Macintyre river); a grey cracking clay (Grey Vertosol); field length 900 m, skip-row cotton with one row in 2 metres width.

<u>1. Three sets of field sampling were undertaken:</u>

Soil cores were initially collected to determine the physico-chemical properties of the soils at each site. Cores were collected to a depth of 150 cm close to each of the head ditch, mid location and tail drain parts of each field (where the drainage lysimeters were to be located), cut into 10 cm lengths and samples submitted for "routine" soil chemical / physical analysis at the Natural Resource Sciences Chemistry Centre (NR&M, Indooroopilly).

Table 1. Location in latitude and longitude of the three experimental sites

Dalby	Mid-field	-27.0214	151.1257
St George	Mid-field	-28.1628	148.6877
Goondiwindi	Mid-field	-28.6035	149.9541

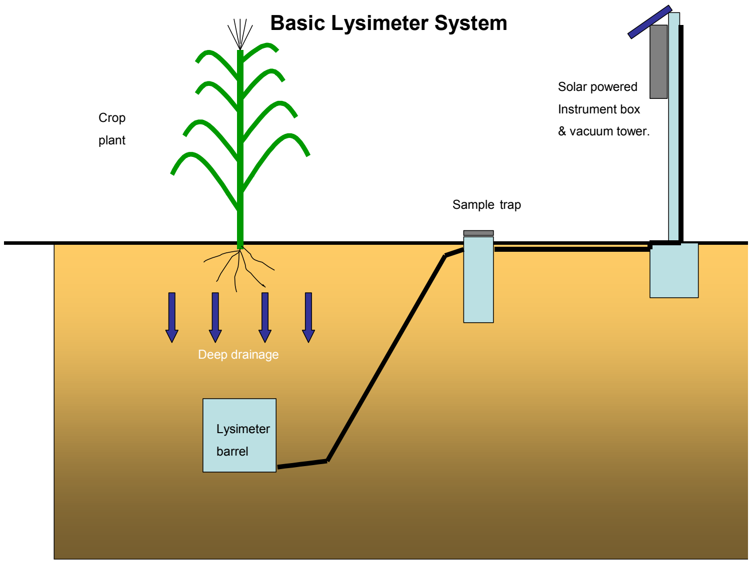

Figure 1. Schematic, cross-sectional view of a lysimeter installation. The lysimeter (at the base of the barrel) sits at 150 cm depth, from the soil surface.

2. Installation of field lysimeters:

Barrel lysimeters were installed near each of the head ditch and tail drain, and at the mid-point between. Figure 1 provides a schematic cross-section of a lysimeter layout with sample trap and vacuum tower positions outside the edge of the field. A lysimeter is a 30 cm diameter (with 35 cm sidewalls) undisturbed soil core, buried in place at 150 cm depth that collects the water exiting the cotton root zone. A low suction was produced by a solar powered 12V vacuum pump suspending a 150 cm column of water in the vacuum tower on the edge of the field. A constant low suction of -150 cm, applied to three ceramic candles in the base of the lysimeter (Figure 2), extracts the water passing through the lysimeter, the water travels to the sample trap and passes through a logged tipping bucket pluviometer (logging the volume of water and event time) before it passes through to collection chambers. In these ways both the electronic and "manually measured" water volumes passing through the lysimeter are recorded.

Two cotton irrigation seasons were monitored at each site (2002-03 and 2003-04). The tipping bucket data were routinely downloaded and the volume of water in the collection chambers recorded. During the season, samples of the irrigation water were collected from the head ditch over several irrigations at each farm for subsequent testing of salinity and sodicity levels.

Figure 2. Installation of a lysimeter. (a) The “Proline” soil sampling rig, used to remove intact columns of soil, (b) the base of the lysimeter with the three ceramic candles in place and plumbed through the lysimeter wall, (c) the lysimeter after the base is sealed with a plastic disc (visible is the DD water collection tube) being lowered back down the hole.

<u>3. Intact soil columns for glasshouse experiment</u>
At each of the three sites, 12 x 30 cm diameter intact cores (90 cm depth) were collected from twelve furrows adjoining the middle lysimeter locations. The 36 cores were transported to a glasshouse at NR&M, Indooroopilly to assess the effect of changes in salinity and sodicity of irrigation water on deep drainage. The glass house set-up is illustrated in Figure 3.

Porous ceramic cups were placed at the base of each soil core and water extraction tubes from these were passed through holes drilled in the plastic to facilitate water extraction as “irrigations” proceeded. Each column had an individual collection vessel which was placed on an electronic balance (maximum weighing capacity of 4000 g; with 0.01 g precision) attached to the data logger, (Figure 3) for continuous recording of real-time DD.

To minimise the preferential flow of water, every effort was made to close air gaps and large cracks in the soil by pre-wetting the columns with distilled water. The soil in the wet columns was left to expand and settle for at least 1 week before the treatments were imposed.

Treatments were four qualities of irrigation water:
- High EC (saline) & High SAR (sodic) (EC = 3 dS/m; SAR > 15)
- Low EC & High SAR (EC < 0.3 dS/m; SAR > 15)
- High EC & Low SAR (EC = 3 dS/m; SAR < 5)
- “good quality” irrigation water (EC < 0.3 dS/m; SAR < 5)

Five litres of water of each quality; forming a 7 cm high head of water on the soil surface, were applied to 3 replications of each soil type and drainage was monitored for 20 days.

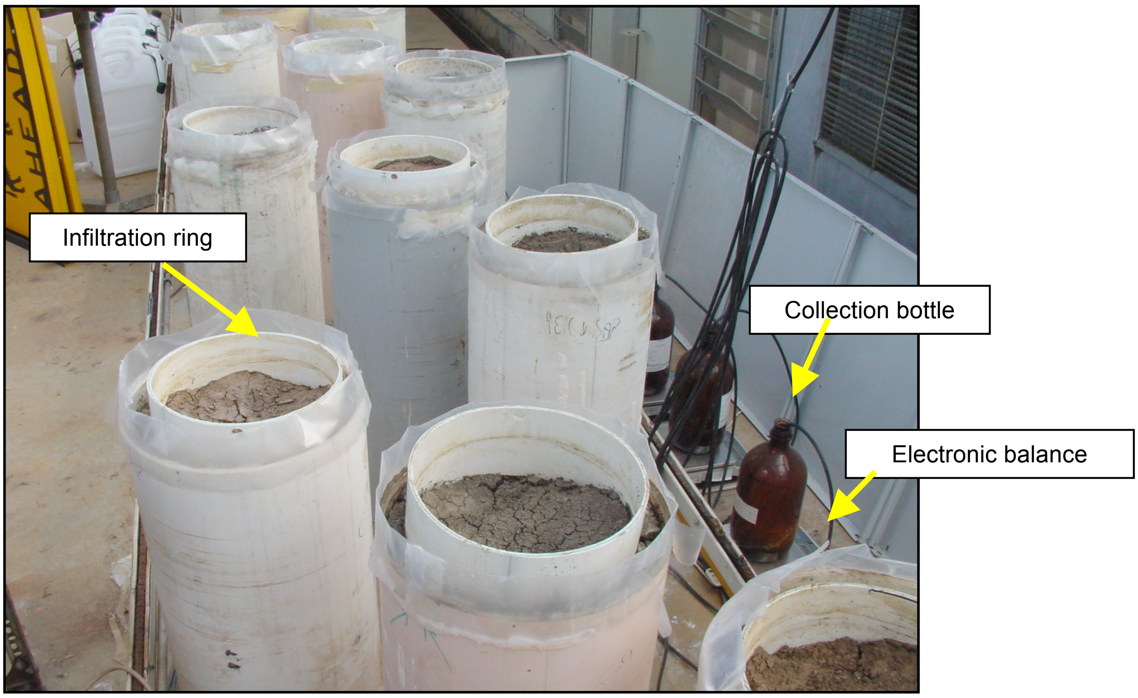

Figure 3. Partial view of the glasshouse trial. Tubing from each core, water collection bottles and weighing balances are visible behind the cores for water collection and continuous logging of drainage water. The PVC ring used in each core to create a constant-head infiltration area (to which the "irrigation" water was applied) is also highlighted.

3. Detail and discuss the results including the statistical analysis of results

Soil physio-chemical characteristics of three experimental sites

Results of the soil physico-chemical analysis supported the initial site selection process, where one aim was to conduct the experimental procedures on three different soils representative of irrigated cotton. Typical within-field variation of soil properties at each site is shown in Figure 4 for the clay content (%) at the head, mid and tail locations for each site. Evident is that variation is commonly less than 10% clay content between in-field locations for any one depth. It is also evident that there is no trend in clay content related to in-field locations; for example, shallow depths of the tail ditch location had the greatest clay % for Dalby and St George soils, and the least for the Goondiwindi soil (Figure 4).

Average clay % for each site demonstrates the strong site differentiation (Figure 5). Dalby had the greatest clay contents to 1 metre depth (>70%), Goondiwindi 50 to 55%, and St George the least (40%) clay content.

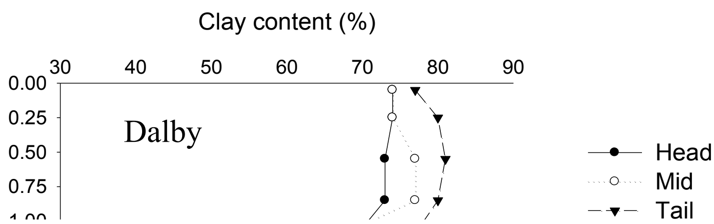

Figure 4. Comparison of clay profiles at each of the head, mid and tail locations of the three experimental sites.

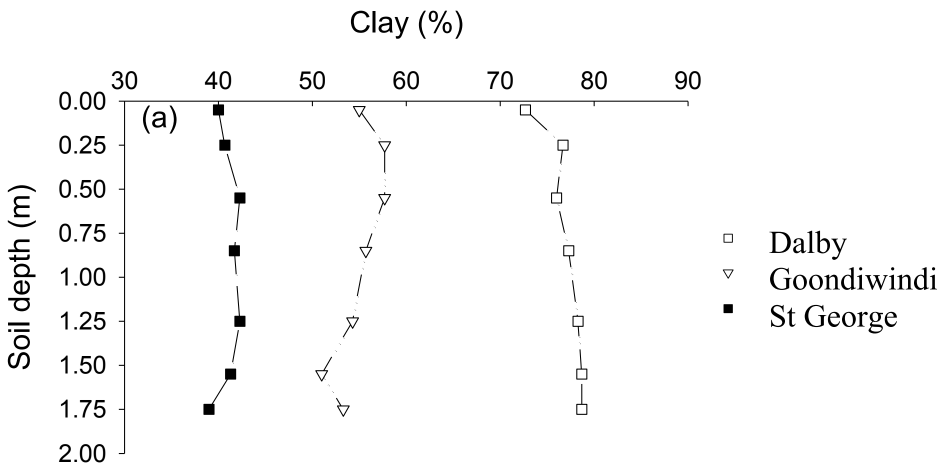

Figure 5. Comparisons of average clay content at each of the experimental sites (averages of the head, mid and tail locations at each site)

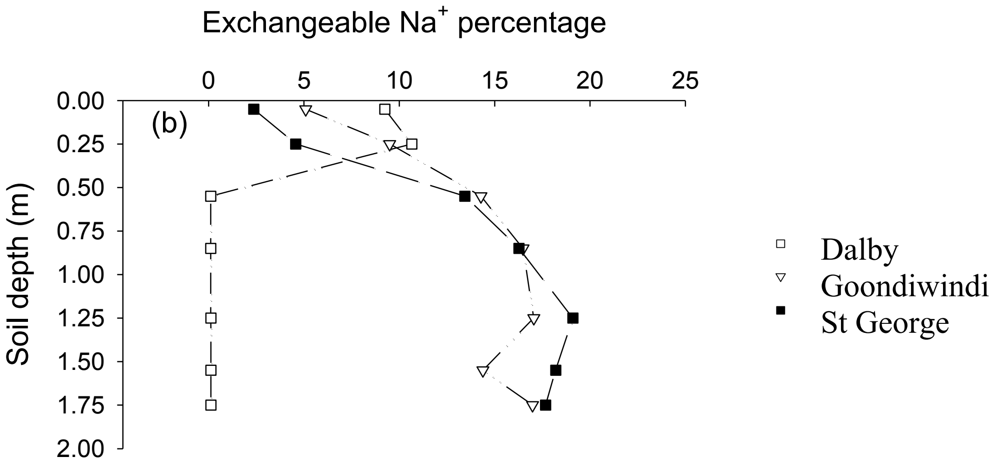

Figure 6. Comparisons of exchangeable Sodium percent (averages of the head, mid and tail locations at each site) from the three experimental sites.

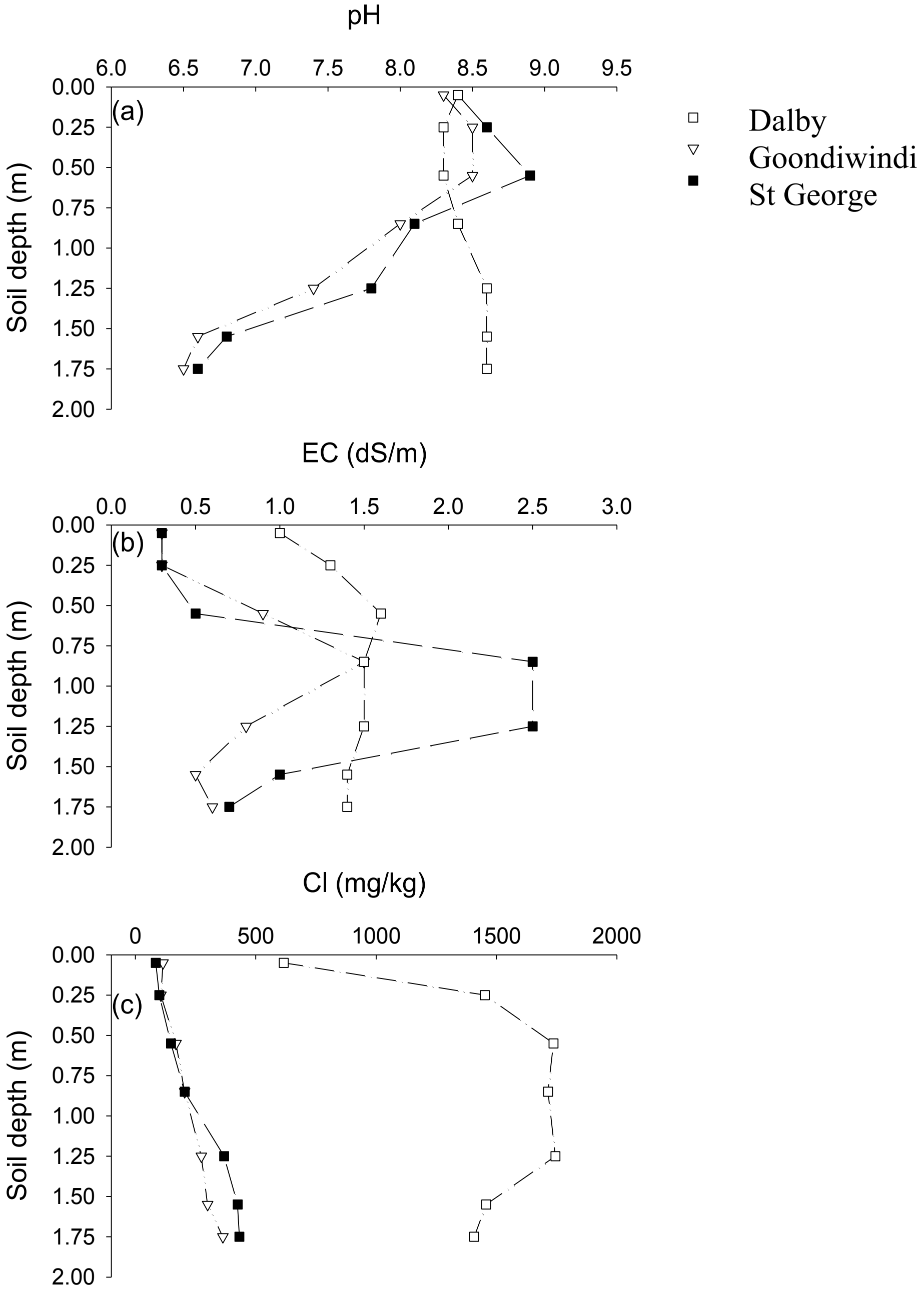

Figure 7. Comparisons of the pH, EC and Cl data (averages of the head, mid and tail locations at each site) from the three experimental sites.

Selected physico-chemical data are presented as averages of the head, mid and tail locations for each of the three sites (Figures 6 and 7).

Both the Goondiwindi and St George sites are neutral to acidic with depth, dropping to pH <7 under 1.25 m. These pH values are unlikely to restrict root development into the subsoil.

Electrical conductivity is by far the greatest in the 80 to 120 cm layer at the St George site, and is most likely linked to the presence of gypsum (calcium sulphate) in subsoil layers at this site. These high values of EC may have strong impact on root development into such "hot" subsoils.

Strong differentiation between the sites is evident in the chloride (Cl) profiles with the Dalby site having almost 3 to 4 times the salt level of the other two sites. This may well be an inherent property on this very heavy (high clay content) soil but, as will be discussed below is probably further exacerbated by the application of irrigation water (from a bore) with high salt levels; evident in Table 2 where the irrigation water at the Dalby site has by far the largest EC and Cl values. These values place the Dalby irrigation water in the "high" water salinity rating of Shaw and Gordon (1997) in terms of plant salt tolerance.

On the other hand, EC and Cl levels in drained water (lysimeter samples) were not related to the levels applied with irrigation water (Table 2). This indicates variation in degree of leaching of salt from the root zone.

Conversely, exchangeable sodium percentage (ESP) is least in the subsoil of the Dalby site (below laboratory detection level in the layers below 50 cm), whereas both Goondiwindi and St George have large ESP values (up to 20) in the subsoil. Such large values will certainly affect water infiltration through the subsoil, as the soil will disperse in the presence of free water in the layers below 75 cm.

Table 2. Average electrical conductivity and chloride contents in water collected at the time of irrigation and from the lysimeter water samples of three sites during the 2002/2003 cotton season.

	Irrigation water samples		Lysimeter water samples	
	EC (µS/cm)	Cl (mg/L)	EC (µS/cm)	Cl (mg/L)
Dalby	3358	942	6703	2803
Goondiwindi	492	79	3805	605
St George	137	14	8775	1333

<u>In-field deep drainage</u>

Results from the lysimeters installed at each site are presented in Figure 8 and Table 3. Time series data from each of the head, mid and tail lysimeters at each site for the 2003-4 cotton season are presented together with the rainfall and irrigation events (Figure 8). Clearly evident at all sites is the relation between water being collected in the lysimeter and the irrigation events. At Goondiwindi and St George the ranking of the amount of DD at the three in-field locations was the same, with the head ditch receiving the most DD, then the mid and the least at the tail ditch end (Table 3). Dalby had a similar trend in the 2002-03 season. These results can be rationalised by the fact that the head ditch end of the field remains inundated for the longest period of time and the tail ditch the least as irrigation siphons are often stopped before the water reaches the tail ditch end of the field, resulting in a very short period of inundation. The 222 mm of deep drainage at the Dalby site during the 2002-03 season can be attributed to the farmer trying to completely inundate the field at the start of the season; aiming for a completely filled soil profile. This value represents almost 33% of the applied irrigation water being lost to DD. Conversely, in 2003-04, the Dalby site had the least amount of deep drainage with the tail ditch having a greater total than the head ditch. At the Dalby site, poor flow through the field exit-drain with some irrigations causes the tail end of the field to remain inundated.

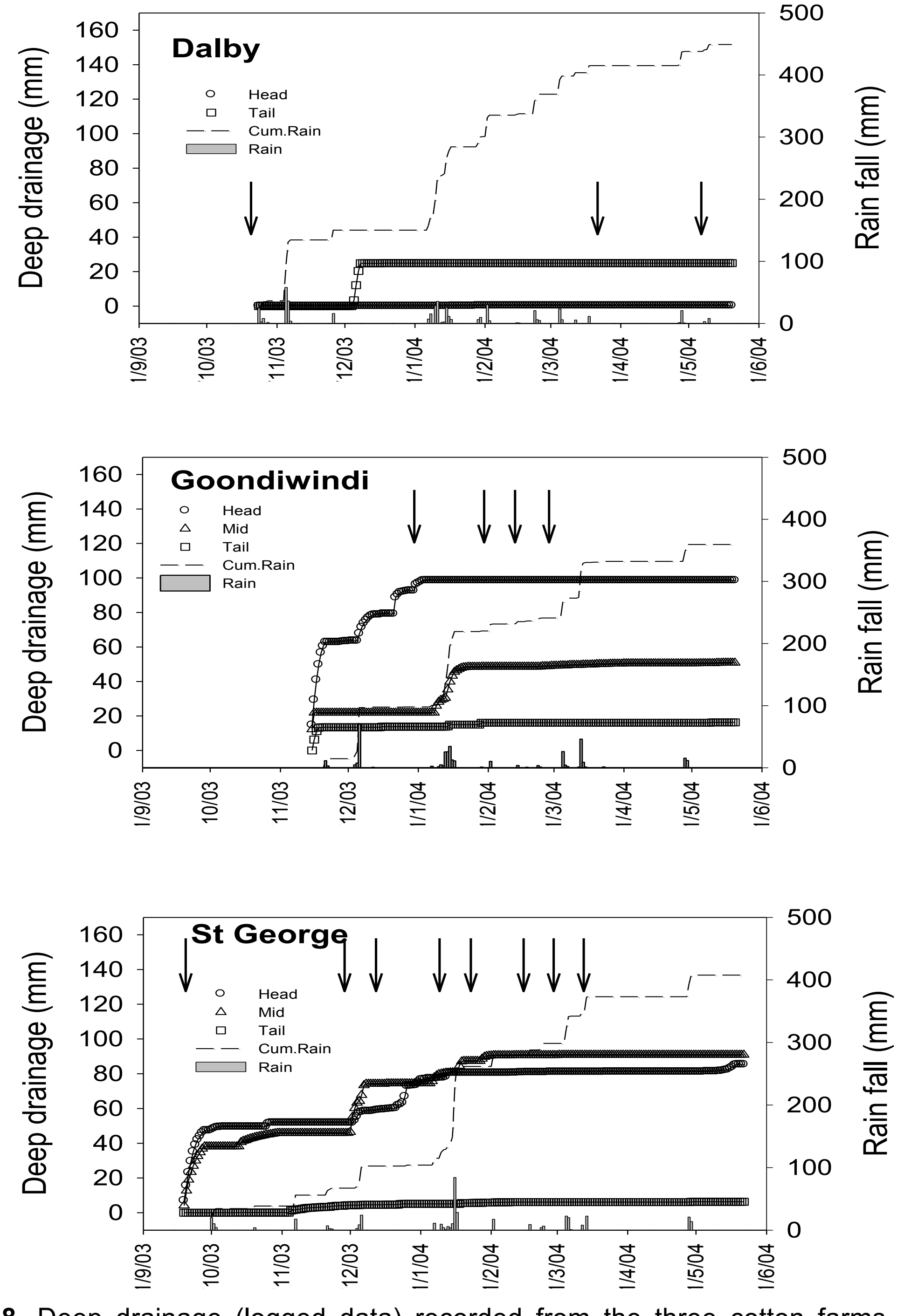

Figure 8. Deep drainage (logged data) recorded from the three cotton farms during the 2003/2004 season. Rainfall and cumulative rainfall are also shown in the figure. (Vertical arrows indicate irrigation events).

In terms of irrigation water applied in each of the seasons, the following data sets were available:

- Goondiwindi received a total of 5.5 ML/ha water in the 2002-3 season (corn); and 4.9 ML/ha in the 2003-4 season (sorghum).
- St George received 9.32 ML/ha in the 2003-2004 season.
- At the Dalby site irrigation water was very scarce in the 2003-4 season and the crop was watered only 3 times; a total of 6 ML/ha of water being applied. The lack of irrigation water in that season is reflected in the very small DD values for that season (Table 3).

Table 3. Lysimeter deep drainage values (mm of water) from logged (pluviometer) data collection.

	Dalby		**Goondiwindi**		**St George**	
	02-03	**03-04**	**02-03**	**03-04**	**02-03**	**03-04**
Head	222	3	114	99	34	91
Mid	n/a	n/a	55	49	16	91
Tail	43	25	14	16	12	6

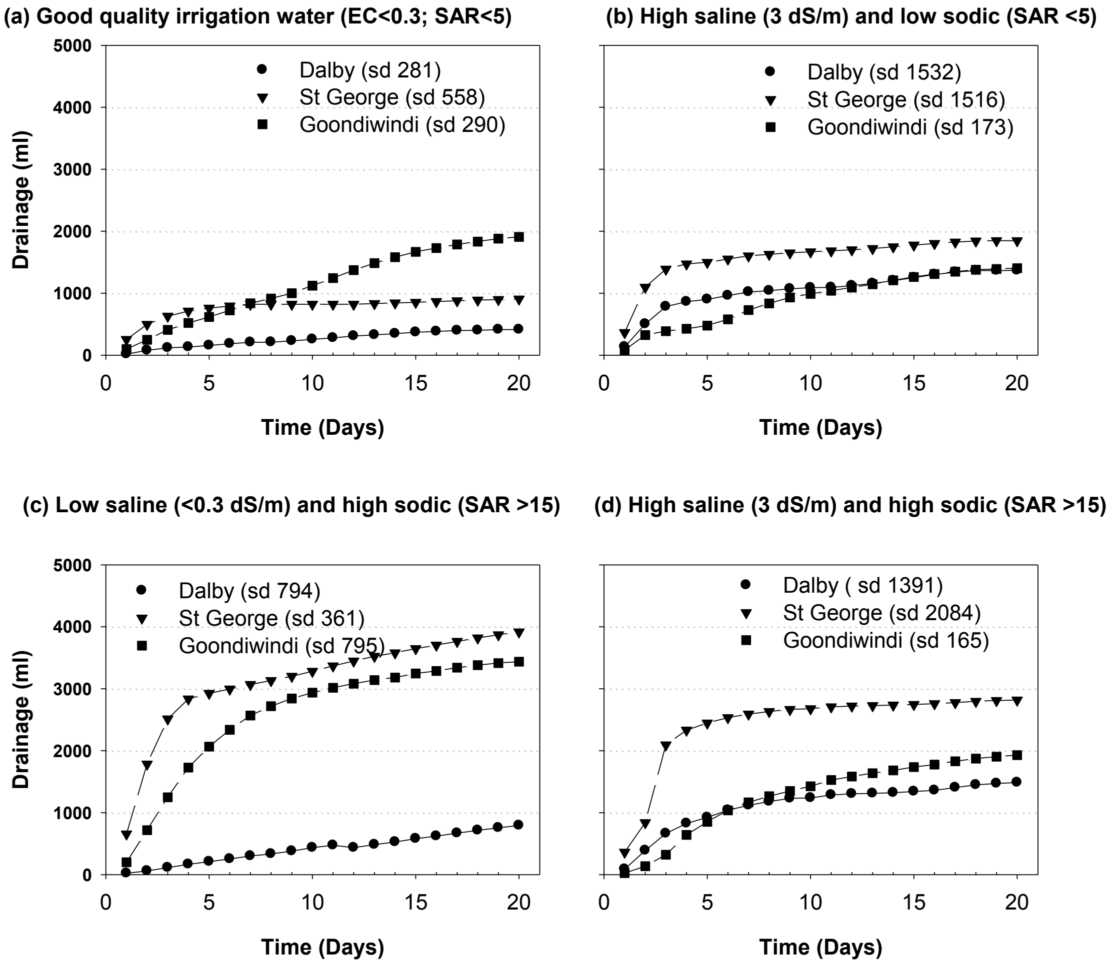

Figure 9 Glasshouse experiment results; cumulative deep drainage through the intact soil cores from each site, as affected by various mixes of irrigation water quality. Standard deviations for the final cumulative drainage after 20 days for each site for each of the water qualities applied are given in parentheses.

Glasshouse experiment (*in-vitro* deep drainage)

In terms of the glass-house experiment, ten days after irrigation with 5000 ml (7.1 mm)of fresh water; the Dalby, St George, and Goondiwindi soils drained 254 ml (0.4 mm), 821 ml (1.2 mm), and 1121 ml (1.6 mm), respectively (Fig. 9 a). Irrigation with high saline and low SAR water resulted in drainage that was 4-fold, and 2-fold greater than irrigating with fresh water in the Dalby and St George soils, respectively (Fig. 9 b). There was no change in drainage with Goondiwindi soil in response to this irrigation water quality (Fig. 9 b). Irrigation with low EC and high SAR water resulted in 2-, 4-, and 3-fold greater drainage in Dalby, St George, and Goondiwindi soils, respectively (Fig. 9 c) compared with irrigating with fresh water. Irrigation with high EC and high SAR water showed 5-, 3-, and 1.3-fold drainage in Dalby, St George, and Goondiwindi soils, respectively (Fig. 9 c) compared to irrigation with fresh water.

To summarise the glasshouse experiment, there was an interaction between soil type (and probably clay content in particular) and water quality on deep-drainage. Drainage was enhanced more by salinity than the sodicity of the irrigation water in the Dalby soil (large clay content), while drainage was enhanced more by the sodicity rather than salinity of the irrigation water in St George (least clay) and Goondiwindi soils, compared to the drainage values from irrigating with fresh water. The results obtained with Dalby soil with high clay content are similar to those suggested by Shaw *et al*. (1994). However, soils from St. George and Goondiwindi showed increased drainage with sodic water and these results are in conflict with the suggestion of Shaw *et al*. (1994). We believe that this unexpected trend in the results can be explained by the presence of large cracks in the soil cores, before the cores were irrigated. The cracks were a result of the soil cores drying in the glasshouse before irrigations began. This level of dryness would be rarely achieved in an irrigated field. Even several attempts at pre-wetting the cores (before irrigations commenced) did not completely remove all the cracks and some remained visible throughout the experiment. It is believed that the cracks led to the preferential and erratic flow of water.

5. Conclusion and outcomes compared with objectives.
What are the "take home messages"?

The project had two principal objectives:

1) To utilise drainage lysimeters to directly measure drainage and correlate responses in column experiments to field response.
2) To assess the effect of increasing salinity and sodicity of irrigation water on the deep drainage in a glasshouse experiment on intact soil cores from three sites

All field installations and glasshouse experimentation were achieved, despite serious underestimation of the scale and time involved with implementing and monitoring both parts of the project. Despite this, several sensible and interpretable results were obtained from both experiments, particulary:

- the link between length of water inundation in the field and subsequent large values of DD, causing the head ditch location to generally provide the largest values of DD
- demonstrating the need to install at least three lysimeters in a field to reflect the strong within-field variation in DD
- the very strong effect of changing sodicity and salinity properties of applied water and subsequent DD and an apparent soil type (clay content) interaction.

In regard to this last point, growers irrigating with saline or sodic waters, and who have no opportunity to reduce potential effects by pre-mixing with purer sources, should aim to minimise excessive losses through deep drainage by minimising in-field inundation times.

6. Detail of how this research has addressed the Corporation's three Outputs - Economic, Environmental and Social?

Economic: The water collected as DD can be regarded as a waste of time, effort and money in pumping, application and monitoring of irrigation water on a cotton farm. Some DD is required, to attain flushing of salts from the soil profile. However, some values measured in the current project are far beyond these requirements. This water is lost to the plant as it by-passes the root zone and moves "off – farm". Considering that when irrigation water is not in short supply, cotton farms apply 5-6 ML/ha/season, deep drainage values of approximately 100 mm (i.e. 1 ML/ha/season) suggest a potential gain in water use efficiency of more than 20% is possible. This water could be used to expand cotton plantings or returned as environmental flows, depending on the circumstances. Guiding principles for reducing DD include decreasing the lag time of water lying in the field, via such practices as increase siphon size, increase "hydraulic head" in the head ditch, steepen slopes in fields, create more rotabucks, etc. In these ways change furrow flow, rate and application time.

Environmental: Firstly, the fate of the water lost to DD is unknown but the spectre of rising water tables under cotton irrigation areas is a possibility. Secondly, the large amount of salt leached away with DD (Table 2) is of concern as this will increase salinity in any rising water table. Further work may ascertain the fate of the DD water and if water tables are rising as a result of excess DD.

7. Summary of the project:

a) Technical advances achieved

The drainage (barrel) lysimeters installed in the three cotton fields performed well and have provided sensible and interpretable data in terms of DD relative to irrigation waters applied. Now that this technology is known and tested, there is scope to install more of these lysimeters in other cotton growing areas. There is also potential to install lysimeters in other potential "water-loss" scenarios associated with cotton production, eg beneath storages, in supply channels and beneath new irrigation techniques, such as travelling and centre pivot irrigators.

a) Other information developed from research

N/A

b) Are changes to the Intellectual Property register required?

No.

8. Detail of plan for the activities or other steps that may be taken:

(a) to further develop or to exploit the project technology.

(b) for the future presentation and dissemination of the project outcomes.

(c) for future research.

Since completion of the project reported here, 4 more cotton fields in the Condamine – Balonne – McIntyre catchment have been instrumented to measure DD. This makes a total of 7 sites (Pittsworth, Dalby (2 sites), Goondiwindi, St George (2 sites) and Dirranbandi) each with 3 drainage lysimeters (located at the head ditch, tail drain and one mid-way between). Additionally, at all sites two more indirect methods of assessing DD have also been implemented to facilitate cross-checking with the continuously monitored DD captured by the lysimeters:

- by comparing infiltration depth (from irrigation advance rate and irrigation flow rate through the SIRMOD model) with antecedent ET (estimated from the FAO56 publication and weather station data) to calculate DD by difference
- using changes in soil salt (chloride) profiles to estimate DD using the SODICS model.

A new project has now been proposed, to commence in mid-2005. This will **continue** current methods of investigating DD, improve on the measurements collected, work towards Best Management Practices (BMP) to minimise DD, as well as monitor large-scale ground water levels. More specifically:

- the lysimeter data at the 21 locations will become more reliable and site-representative with time as the lysimeters "merge" into and become "one" with the soil in the field
- to date, all growers with lysimeters on their farms have continued their normal practice. In this way, the data collected are reflecting "current industry practice", on a range of soils.
- In the 2nd and 3rd years of the project we plan to investigate changes in on-farm practice to reduce DD. Two ways are foreseen:
  - on the current lysimeter sites: increase siphon size, increase "hydraulic head" in the head ditch, create more rotabucks, etc; in this way – change furrow flow, rate and application time.
  - on a new site in the Dalby area, install lysimeters in fields, irrigated with different furrow lengths and travelling irrigator (TI) treatments – to investigate the potential water savings and reduced DD (TI is currently seen by many growers as the "irrigation future" of cotton due to ease of use and improved WUE).

Value-adding will continue at the 7 lysimeter sites in their role as key experimental sites for the cotton industry. For example, projects which will commence at selected sites by May 2005 (with others expected) are:

- Dr Bryce Kelly (Univ. Technology, Sydney) will install and check his soil resistivity equipment at two of the lysimeter sites; evaluating the movement of soil water after an irrigation
- Four (new) barrel lysimeters will be installed around the one large lysimeter (funded by CRDC) at Myall Vale – to cross-check data collected in the large lysimeter and extrapolate the data across the experimental site (head ditch, mid and tail locations).
- Dr Naidu Bodapati (NR&M) will investigate the interaction between soil and irrigation water chemical properties as it affects soil crusting, soil structure and the potential to alleviate poor water quality and soil crusting with calcium additives (gypsum, lime etc)

9. List the publications arising from the research project and/or a publication plan. (NB: Where possible, please provide a copy of any publication/s)

The decision was made to hold-over publications till the end of the 2005 cotton season when up to three seasons of data will be available to publish.

A paper has already been reviewed and accepted for presentation at the IAA Conference, Townsville in May 2005 entitled: "Improved measurement and prediction of deep drainage under irrigated cotton fields in the Condamine – Balonne – McIntyre catchments and likely groundwater responses" by: D. McGarry, T. Gunawardena, E.A. Gardner & G. Millar

10. Have you developed any online resources and what is the website address?

Not to date, but plans have been made to implement this in the Winter of 2005 when up to three seasons of deep drainage data will have been analysed and interpreted.

11. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. Where possible include a statement of the costs and potential benefits to the Australian cotton industry or the Australian community.

In RWUE1 the cotton industry demonstrated water savings equivalent to 68, 000 ML, giving capacity to produce an extra 120, 000 bales of cotton. However, the industry continued to recognise that a continuing gap in improving water use efficiency is its inability to measure deep drainage (DD), and considered this a “major gap” in measuring a whole-of-farm water balance.

Using average data values from the current project, and considering that most irrigation cotton farms apply 5-6 ML/ha/season, deep drainage values of approximately 1 ML/ha suggest a potential gain in WUE of 20%. This equates to an annual saving of 324, 000 ML of irrigation water across the whole industry, with potential for either increasing production by 184, 000 additional bales of cotton, or increased water for other end-users including environmental flows.

Executive Summary

The current project was devised in the knowledge that increased sodicity and salinity of percolating water will alter the saturated conductivity of many soils, especially sodic soils. Additionally, on commencement of the project the Cotton industry had minimal data or experimentation on the scale or driving forces behind deep drainage (DD) with furrow irrigation.
The project had two principal objectives: to assess the effect of increasing salinity and sodicity of irrigation water on the DD under various cotton soil types, and to utilise drainage lysimeters to directly measure DD and correlate responses in column experiments to field response.
To obtain data for the first objective, a glasshouse experiment was conducted to assess the effect on DD of changes in salinity and sodicity levels, waters being applied to large intact cores collected from each field site. For the second objective, nine drainage lysineters were installed in 3 cotton fields (3 lysimeters over each field) and data collected over a period of two cotton seasons.
There were four major sets of results. Firstly, physico-chemical analysis of the soils (to 150 cm) at each site, showed the three sites to be quite different, particularly in their clay content being on average 75%, 55%, and 45% for the Dalby, Goondiwindi and St George sites, respectively.
Secondly, the quality of the irrigation water applied at each site was quite different, in terms of its salinity, with electrical conductivity of 3358, 498 and 137 (µS/cm) for Dalby, Goondiwindi and St George, respectively.
Thirdly, the drainage lysimeters (located at 115 to 150 cm below the soil surface collected water that is deemed "lost from the cotton root-zone"and hence is deep drainage. At the Goondiwindi and St George sites in both seasons (2002-3 and 2003-4) the ranking of the amount of DD at the three in-field locations was the same, with the head ditch receiving the most DD, then the mid and the least at the tail ditch end. Long-term inundation at the head ditch rationalises these results, whereas the tail end may remain dry if irrigation siphons are stopped early. In terms of quantities of DD, the Dalby site had the greatest recorded DD; 222 mm (= 2.2 ML of water) at the head ditch end in the first season but the other two sites also recorded several instances of >90 mm of DD in one season (0.9 ML) at the head and mid field locations.
Fourthly, in a glass house experiment, irrigation with high Electrical Conductivity (EC) and low Sodium Adsorption Ratio (SAR, a measure of sodicity) water increased drainage by 4, and 2 fold in Dalby and St George soils, respectively, compared with irrigating with fresh water; however, Goondiwindi did not show any change. Irrigation with low EC and high SAR water resulted in 2, 4, and 3 fold greater drainage in Dalby, St George, and Goondiwindi soils, respectively compared to fresh water. Irrigation with high EC and high SAR water showed 5, 3, and 1.3 fold drainage increase in Dalby, St George, and Goondiwindi soils, respectively compared to fresh water. These results demonstrate an interaction between soil type (probably clay content) and water quality on deep-drainage. Water lost to deep drainage was increased more by salinity than sodicity of the irrigation water in Dalby soil (high clay content), and more by the sodicity rather than salinity of the irrigation water in St George and Goondiwindi soils.