HEALTHY CROP AND HEALTHY GROUNDWATER – SUGARCANE IN THE BURDEKIN DELTA.

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In the Burdekin delta good soils, favourable climate and plentiful water combine to produce some of the highest yielding sugarcane in Australia. The freshwater aquifer system, which underlies the delta, is a major contributor to the prosperity of the region and its maintenance has been the responsibility of the Burdekin Water Boards since the mid-1960's.

In the face of rising pressure from water resource legislation and environmental issues, particularly due to the proximity of the Great Barrier Reef, a coordinated research program (the Lower Burdekin Initiative) has been formed. The initiative seeks to ensure that future management decisions and evaluations of the system are based on good science and robust data.

A major effort has been launched as part of the LBI to quantify through measurement and modeling the quantity and quality of water draining beneath sugarcane crops with potential to reach the aquifer. The aim is to highlight those combinations of soil type, and agronomic, irrigation and soil management practices, which have the least impact on aquifer health.

In this paper we present the first systematic aquifer extraction data from the Burdekin delta. Data at the end of the first year of the study show that measured application rates at the selected sites varied from 10-24 ML/ha and that 4-62% of this water plus rainfall drained beneath the crop rootzone. Water use efficiency varied from 3-14 t/ML and economic analysis of the production figures suggest that the current water pricing in the Burdekin delta profit is not a major driver for reducing water use.

INTRODUCTION.

Ideal climate and plentiful water combine to make the Lower Burdekin delta region of Queensland (Figure 1) one of the highest yielding sugarcane areas in Australia. Part of this success is due to the large aquifer underlying the area and supplies irrigation water for 40,000 ha of sugarcane and drinking water for the population of 20,000 people. Annual rainfall for the region averages 1032 mm with 60-80% falling in the December – March 'wet' season. Mean annual evaporation is 1800 mm. Soils in the Burdekin delta are predominantly freely draining alluvials with highly variable layering. Small areas of cracking clays are also present.

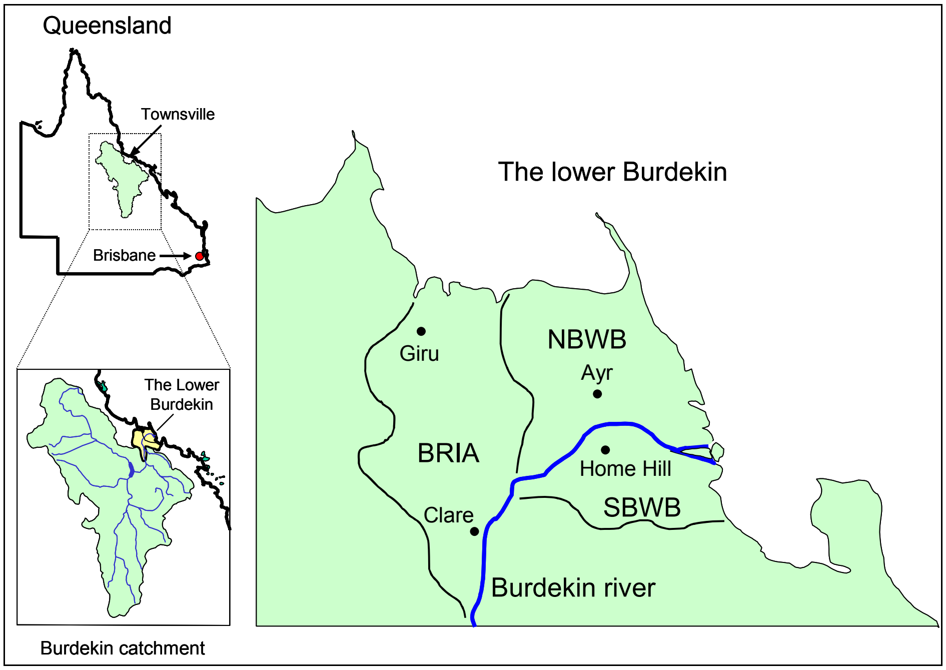

Figure 1. The Burdekin delta region showing population centres and areas covered by the North and South Burdekin Water Boards (NBWB and SBWB) and Burdekin River Irrigation Area (BRIA).

The unconfined aquifer is in contact with the sea and an active artificial recharge program carried out by the North and South Burdekin Water Boards since the 1960's aims to maintain sufficient aquifer potential to control the intrusion of seawater. Methods used for artificial recharge are direct pumping from the Burdekin River for direct recharge through large recharge pits, *recycling* and *water spreading* (Bristow et al. 2000). *Recycling* refers to the practice where excess irrigation water from private production bores drains past the crop root zone and returns through the soil back to the groundwater. It is felt that this helps with the recharge and maintenance of groundwater levels. *Water spreading* refers to the practice where Board pumped river water that is too turbid to be used for artificial recharge via the recharge pits (due to pore-clogging) is made available across the scheme as surface water for farm irrigation. This helps spread the silt load across the farmland and, while keeping the silt load out of the recharge pits, is thought to benefit the soils and assist the replenishment process. A schematic illustrating water management processes in the lower Burdekin is shown in Figure 2.

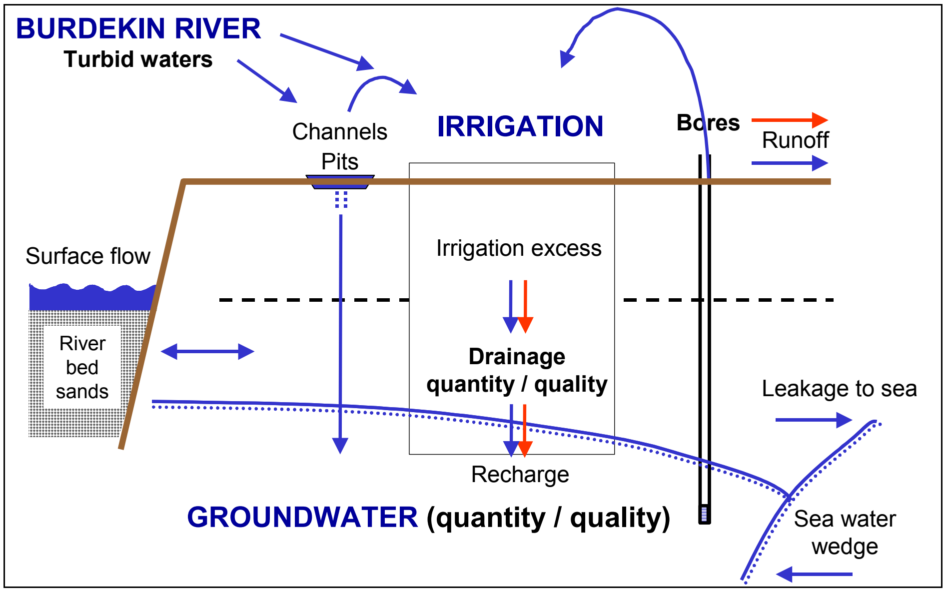

Figure 2. Water balance components of the Burdekin Delta.

Approximately 95% of the sugarcane in the Burdekin delta is furrow irrigated. Few studies have investigated the amount of water extracted from the Burdekin delta aquifer for irrigation. Tilley and Chapman (1999) reported a mean irrigation application of 13-25 ML/ha. The Burdekin Delta Groundwater Model states a range from 11-20 ML/ha (Arunakumaren *et al*, 2000). Estimates of deep drainage are also rare and based on single irrigation events with Holden *et al* (1997) calculating a range of 43-60% and Raine (1995) 39-60% of irrigation water draining beneath the crop rootzone. Groundwater pricing has changed recently from a levy on production to an area-based charge of $48/ha for the South Burdekin Water Board and $60/ha for the North Burdekin Water Board. This charge is in addition to electricity costs for pump operation. Surface water, which comprises 20-30% of the total water application, is charged separately on a volumetric basis.

The quality of water passing through our catchments is increasingly in focus for its effects on environmental condition. One need only consider the frequency of media articles featuring water related matters to gauge the increasing importance of this part of our environment. In response to rising pressure from water resource legislation and environmental issues, particularly due to the proximity of the Great Barrier Reef, a coordinated research program, the Lower Burdekin Initiative (Bristow et al. 2001), has been formed. The initiative seeks to ensure that future management decisions and evaluations of the system are based on good science and robust data.

Two paddock scale projects funded by the National Program for Irrigation R&D and Queensland Rural Water Use Efficiency Initiative (R&D) are working together to measure and regulate the quantity and quality of water draining beneath sugarcane crops with potential of entering the groundwater. Information from the first comprehensive soils mapping survey of the Burdekin delta currently underway will enable up-scaling of these results to regional level. This paper deals with the first year of the study and presents basic information regarding irrigation application rates, and water use efficiency data along with economic analyses.

METHOD.

Water Balance.

During the 2000 year eight irrigation blocks were chosen across the Burdekin delta to meet the twin objectives of covering the range of representative soil types and a ‘one pump/one paddock’ configuration to simplify record keeping. Details on block soil types and sizes are given in Table 1.

Table 1. Irrigation trial experimental block details.

Farm #	1	2	3	4	5	6	7	8
Size (ha)	8.3	10.2	5.5	8.9	12	14.7	7.8	5.5
Soil Type	Tenosol	Vertosol	Kandosol	Vertosol	Kandosol	Kandosol	Hydrosol	Tenosol

To measure irrigation (I) flow meters were installed on the pumps supplying each site. Length and time of each irrigation set were recorded by the grower. Many blocks with permeable soils have furrow ends blocked ensuring little runoff (Ro) occurs. For these sites runoff was estimated as 10% of rainfall+irrigation. At sites where runoff is significant volume was measured with flumes and logging depth sensors.

Evapotranspiration (ET) was measured for site 2 using Bowen Ratio equipment (Inman-Bamber, unpublished data). ET for site 8 was modelled using the APSIM-Sugarcane model with the SWIMv2 water balance module. ET for all other sites was estimated using the ET/yield relationship developed by Kingston (1994). All other weather components including rainfall (R) were gathered from local Automatic Weather Stations. Change in water stored in the soil over the whole season was assumed to be zero.

Deep Drainage (Dr) was calculated from the soil water balance by difference:

$$Dr = (ET + Ro) - (I + R)$$

PRODUCTION AND ECONOMICS.

Cane yield and sugar content were taken from mill receipts. Economics performed on the production figures applied average costs and returns as described by Qureshi *et al* (2001).

RESULTS AND DISCUSSION.

Water application and Evapotranspiration.

A summary of water balance components is presented in (Table 2). Irrigation application varied from 10 – 24 ML/ha for the first season of the trial while ET ranged from 9-16ML/ha (Figure 3). Soil type and management were the major variables. In general high water application is correlated with soil permeability. An exception is the medium clay soil of Farm 7. Contributing to the high application of this farm is the well-structured nature of the soil and the irrigation water electrical conductivity of ~1 dS/m. The lowest water user (2) is also a block with medium clay but a lower infiltration rate means this field is more prone to runoff than deep drainage. This is also the only block to apply less irrigation that total ET and therefore use a proportion of rainfall. In this climate rain falls in large, intense events with high runoff rates which makes utilisation difficult.

Table 2. A summary of the first years crop yields and water balance components (ML/ha)

Farm #	1	2	3	4	5	6	7	8
Yield (t/ha)	141	130	88	Plant 2001	94	100	84	144
ET	13	13	9		10	10	9	16
Rain	8	8	8		8	8	8	8
Irrigation	18	10	11		11	18	24	24
Runoff	3	5	2		2	3	3	1
Drainage	10	1	8		7	13	20	15
Upflow	0	1	0		0	0	0	0

Yields ranged from 84 – 144 t/ha with a mean of 112 t/ha. The mean yield for the delta mills for the 2000/1 season was 98 t/ha. In general, the highest yielding blocks were also the highest water users. However, the highest yields also came from the best cane growing soils in the region.

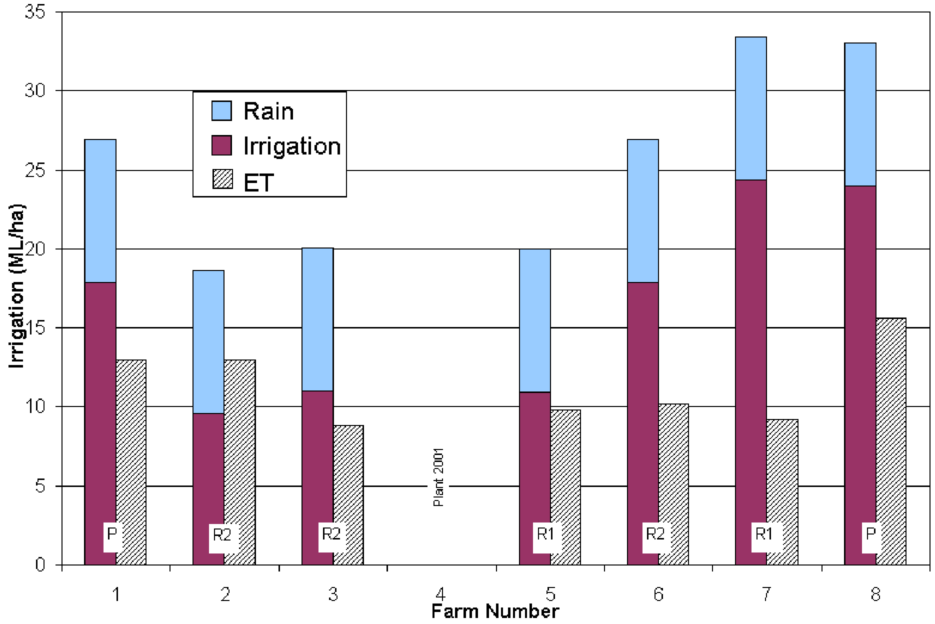

Figure 3. Block irrigation application, rainfall, ET and ratoon.

DEEP DRAINAGE.

The deep drainage estimate for the eight sites ranged from 1-22 ML/ha (Table 3). This equates to a range of 4-62% of applied irrigation plus rainfall. As with irrigation application the deep drainage values reflect both soil type and management practice. The field with the least drainage reflects a combination of low conductivity soil, moderate yield and a farmer committed to reducing water use through strict irrigation scheduling. The higher losses are produced by the more permeable soils or where lower yield has resulted in less crop extraction. These drainage rates represent the ‘recycling’ process in action where water that is not used by the plant percolates back to the aquifer where it is available for repumping. From a water perspective the only negative consequence of this cycling is increased pumping costs. However, the issue of solute transport with the drainage water has been raised as a possible threat to aquifer health. It is this facet that is receiving focus in the second year of the study.

Table 3. Deep drainage as volume and percentage of irrigation plus rainfall.

Farm #	1	2	3	4	5	6	7	8
Drainage (ML/ha)	8.8	0.8	8.6	Plant 2001	7.9	14.5	19.9	11.2
% of irrigation	40	4	44		38	50	62	49

WATER USE EFFICIENCY.

Water Use Efficiency (WUE), in terms of tonnes of crop produced per megalitre of water applied, was calculated from the water application and yield data. Site 2 produced the most cane per ML of water applied, with 14 t/ML. The lowest value was 3 t/ML. Factors which play a major role in determining WUE are soil type, management practices and field configuration.

Table 4. Water use efficiency (tonnes of sugarcane per ML irrigation applied).

Farm #	1	2	3	4	5	6	7	8
WUE (t/ML)	8	14	8	Plant 2001	9	6	3	6

ECONOMICS.

The question "Is the most water efficient grower also the most profitable ?" has been posed to researchers working in the lower Burdekin, and our data has been used to try to address these issues given that environmental management is more likely to be effective when agricultural systems are profitable. Applying average costs and returns to the data presented above enabled a Gross Profit Before Tax (GPBT) to be calculated. The effect of tax has not been included as it is very specific to individual business structures. The GPBT showed a large range ($200-$2200/ha) and followed the same ranking as the yield (Figure 4). The major point to make here is that the cost of water is low enough to have little effect on profit regardless of the amount applied. For instance, Site 1 produced similar yield to Site 8 using 6 ML/ha less water, but GPBT is little changed at $2220 and $2270, respectively. To answer the question posed, the most *water* efficient grower received only 70% of the profit of the most *financially* efficient grower.

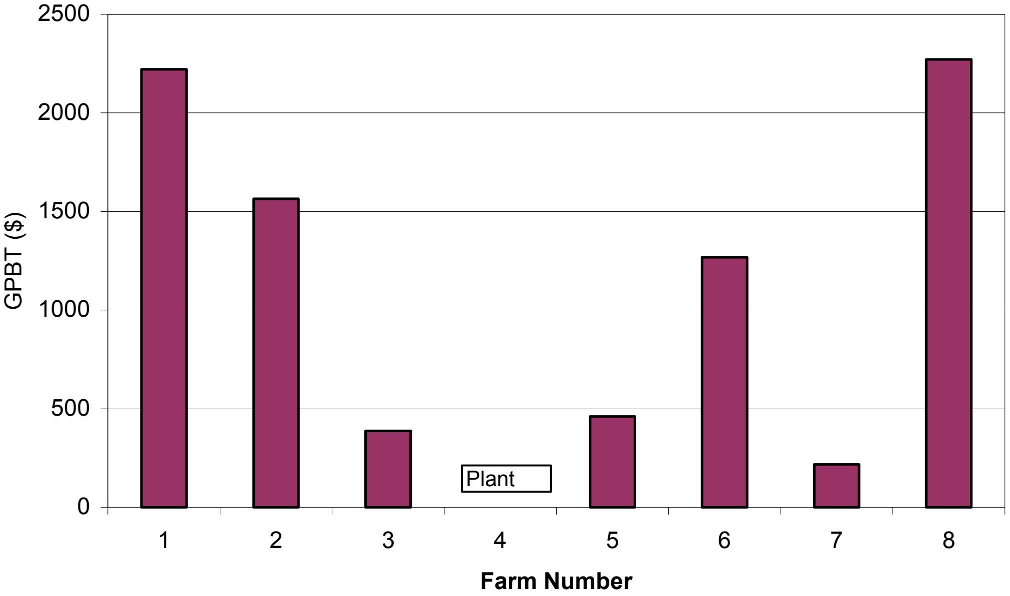

Figure 4. Gross profit per hectare before tax.

To analyse how much value is being extracted from the water applied the GPBT was divided by the total irrigation application. This led to a marked change in ranking with values ranging from $10-$160/ML (Figure 5). The combination of good yield and low water application has meant Grower 2 extracts significantly greater value from the water applied. In places where water is scarce or of higher cost this may have a large bearing on which crops/soils are chosen for irrigation, which irrigation systems are used and how much investment is made in management tools.

Economics is often used as the classic extension message to support the need for change, as adoption of a changed practice can be markedly improved if it can be shown to offer increased profit. The challenge in the lower Burdekin however is that the information presented above shows that the economic message cannot be used to promote the “efficient” use of water. If by “efficient” use of water one means use of less water, then the current price of water is too low for there to be any significant change in water use. Before progressing such changes however one needs to be very clear what the objectives are. For the system as a whole to work effectively into the long-term, water management practices must deliver **BOTH** production (profitable) and environmental benefits.

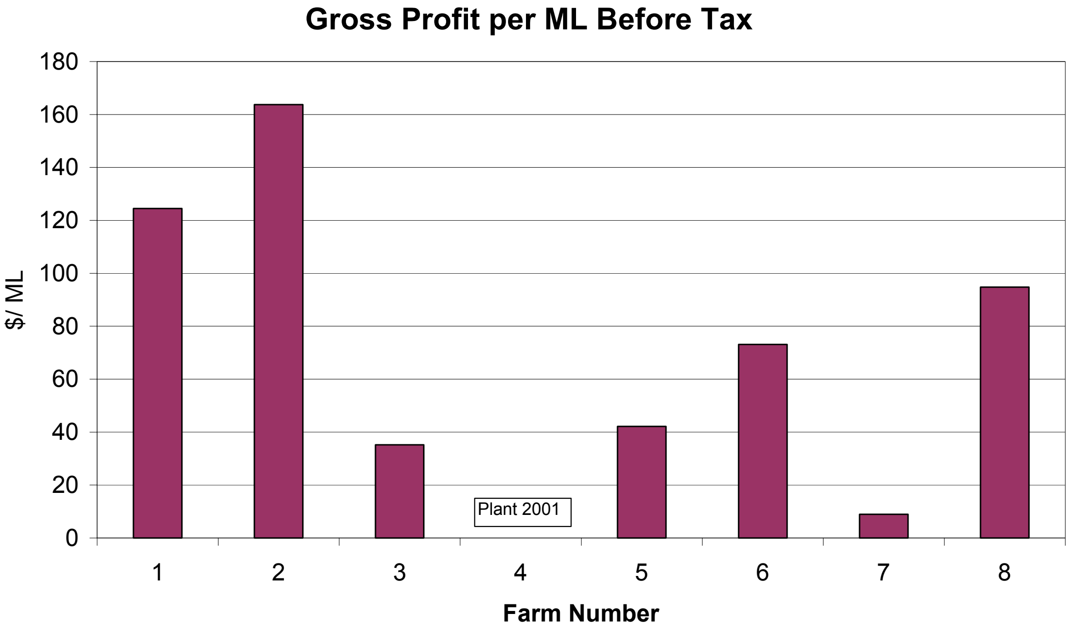

Figure 5. Value extracted from a ML of water.

SUMMARY

The overall goal of this work is to ascertain if solutes drained with excess irrigation water are likely to have an adverse effect on the Burdekin groundwater systems. In the initial season we have concentrated on gaining basic background data on how much water is applied to sugarcane blocks in the Burdekin delta. Many estimates have been made of groundwater extraction for irrigation but without measurement capability much uncertainty exists. Although only 8 flow meters have been installed so far it is clear a wide range of soil/management combinations have been identified. Deep drainage rates have varied from a small percentage of applied irrigation plus rainfall (4%) on a block with medium clay where irrigation is scheduled according to strict guidelines, to a large percentage (62%) on a highly permeable soil. The drainage rate was also exacerbated by small crops with low yield through reduced water extraction. With such high drainage rates knowledge of both the solute content and fate of the solutes is critical in assessing the effect on aquifer health. This is the focus of the next phase of this study.

Preliminary economic analysis also demonstrated that current water pricing in the delta precludes the use of ‘profit’ alone as an extension message to improve water use efficiency. Other aspects such as reduced labour and potential environmental impacts need to be investigated if improved water use efficiency is the key objective. However, when introducing new water management practices careful consideration must be given to their effects on the whole system. For instance, experience has shown the managers of the Burdekin aquifer that to maintain control of water table height requires a continuous hydraulic link from surface to aquifer. In drought times drying of the subsoil has decreased hydraulic conductivities and broken this link, making control of water tables more difficult. This is why structures such as the Lower Burdekin Initiative are important in that they allow a whole of system approach to resource management issues, with a goal to optimise both the production and environmental aspects simultaneously.

A high level of pressure is currently being placed on producers/ water resource managers from environmental agencies and interest groups. It is the goal of this study, as part of the Lower

Burdekin Initiative, to augment the small set of currently available data and enable both informed resource management decision making and an open and fair assessment of current and future consequences of agricultural management on environmental quality.

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