# Bales per megalitre

## – an industry evaluation of the 2006–07 season

**David Williams[1] & Janelle Montgomery[2]**

NSW Department of Primary Industries & Cotton Catchment Communities CRC, Dubbo [1], Moree [2]

**IN A NUTSHELL**

- The performance indicators for water efficiency in cotton growing are generally not well defined and calculations have not been standard across the industry
- A study of 36 farms has been analysed and some useful benchmarks established for comparison of water use between farms and regions, and across seasons
- The most meaningful water use index for comparing irrigation water use was gross production water use index (GPWUI), as it relates total production to the total amount of water used – the average industry GPWUI was 1.13 bales/ML
- Based on performance indicators of the 'top' 12 farms (on the basis of crop water use index) it was calculated that under best management practice cotton growers across the industry should be targeting a GPWUI of 1.39 bales/ML

***Benchmarking is crucial if an irrigation enterprise is going to improve its water use efficiency. Knowing how you are performing compared with your region or industry allows continuous improvement in management and water use. Unfortunately irrigation benchmarking data has in the past not been well recorded.***

The performance indicators for cotton growers are generally not well defined and calculations have not been standard across the industry. We talk about bales (a bale is 225 kg of clean cotton lint) per megalitre, but what do we mean?

The cotton industry has been developing an on-going process to capture water use information from growers and consultants. There are currently web-based tools available to collect this information, including the Water Benchmarking Tool (Cotton Community Catchments CRC and CRDC 2007) and the commercially available WaterTrack Rapid™. The significance of these tools is that calculations of water use indices are standardised and are defined.

## Data collection

In order to establish a set of industry-wide data for setting benchmarks, water use figures for the 2006–07 cotton season were collected from 42 cotton farms from Hillston in southern NSW to Emerald in Queensland using Aquatech Consulting Pty Ltd's online calculator WaterTrack Rapid. This water balance model provides a simple approach to the rigorous calculation of essential irrigation performance indicators and is an important starting point in establishing the water use efficiency of a farming operation.

Of the 42 farms visited, 36 farms had complete sets of data. The data collected included yield from ginning reports, several water input values (incorporating combinations of rainfall, soil water, storages, harvested, pumped), irrigation dates and the identification of soil type based on water holding and infiltration characteristics.

WaterTrack Rapid obtained calculated evapotranspiration ($ET_o$) and rainfall from SILO online. To determine crop evapotranspiration ($Et_c$), the WaterTrack Rapid calculator combined the $ET_o$ values from SILO with a set range of crop coefficient ($K_c$) values for cotton.

## Information output

WaterTrack Rapid generates two reports.

### *1. Water Summary Report*

A Water Summary Report provides a simple water balance which includes the total water inflow (water diverted, change in storage volumes, overland flow harvested and effective rainfall), crop transpiration figures which provide an accurate indication of the amount of water required per hectare to produce the crop in that season and total available water losses. Simply subtracting crop water use from the total amount of water used on the farm to grow the crop, the volume of water not used by the crop is obtained. This figure is the amount of water surplus to crop production and is known as "losses". With WaterTrack Rapid all farm water losses are combined into a single figure and these losses include:

- all seepage and evaporation losses from supply systems, ring tanks and dams, drainage and tailwater systems
- infield losses such as evaporation from the soil surface and deep drainage
- rainfall run off that is not harvested.

### *2. Performance Indicators Report*

This report calculates a number of performance indicators which benchmark irrigation water use and performance. They include:

- **Crop water use index** (CWUI), which relates the total production to the amount of water consumed by the crop (crop evapotranspiration). Although interesting to see what amount of water the crop has actually consumed, this index is dependent mostly upon non-irrigation related factors such as variety, disease, pests, nutrition and soil constraints and can only be improved by increasing yields. It is not a useful index for benchmarking irrigation water use but it is useful for estimating potential crop water use.
- **Irrigation water use index** (IWUI), which relates total production only to the amount of irrigation water supplied to the farm (or pumped). *It does not include rainfall or soil moisture* and is therefore only useful for comparing nearby fields or farms in the same season.
- **Gross production water use index** (GPWUI) which relates total production to the total amount of water used, ie irrigation water, effective rainfall and soil moisture. It is a more meaningful water use index for comparing irrigation water use between farms and regions and across seasons.

WaterTrack Rapid reports contain a number of other performance indicators along with definitions that explain their origin and relevance of these figures.

## Seasonal factors for 2006–07

The 2006–07 season was very dry. Soil profiles and channel pads were dry and few irrigation storages were used. First irrigations used a lot of water as did any transfer of water around farms. There was little to no in-crop rainfall across all regions. Surface water allocations too, were very low or non existent. Groundwater and carryover of surface water allocations made up the bulk of the water used. Most growers grew a cotton mono crop and areas were down significantly on past seasons.

## What the data tells us

### *1. Variations in whole farm water loss*

Figure 1 shows the 36 farms, with complete data sets, ranked by their **total water loss** (ML/green ha). Each farm is in the same position for each grouping. Also shown are the corresponding **crop yield** (bales/ha), total water inflow (ML/green ha) and **crop transpiration** (ML/green ha). The averages were only calculated for the 29 farms that had a positive total water loss.

Interestingly, an error arose in the estimation or measurement of water volumes on farm. This showed up in the WaterTrack Rapid report with seven farms having negative total water loss (Figure 1). In essence, it means that the total amount of water used to grow a crop was less than the actual crop water use. As total water use includes water pumped, storage volumes and harvested rainfall, some of which are not metered, it is easy to understand that inaccuracies can occur. This suggests that it is likely the **total water inflow** figure was underestimated. If these seven farms had underestimated their total water loss, then it could be assumed that some of the farms with positive losses have also underestimated their total water inflow. If this is the case then the average total water loss could be higher than stated. Clearly, measurement of water volumes, particularly on farm, needs to be improved significantly.

The average water loss (from the 29 farms with positive losses only) was 2.64 ML/green ha. This was around 25% of all water used on farm for the crop, ie water diverted from river and/or bores, water harvested on farm, effective rainfall and soil water. Therefore on average, farms used around 75% of their water through the plant. In this survey, the six farms with the highest combined farm water losses were only averaging around 60% of their total water through the crop in a productive manner.

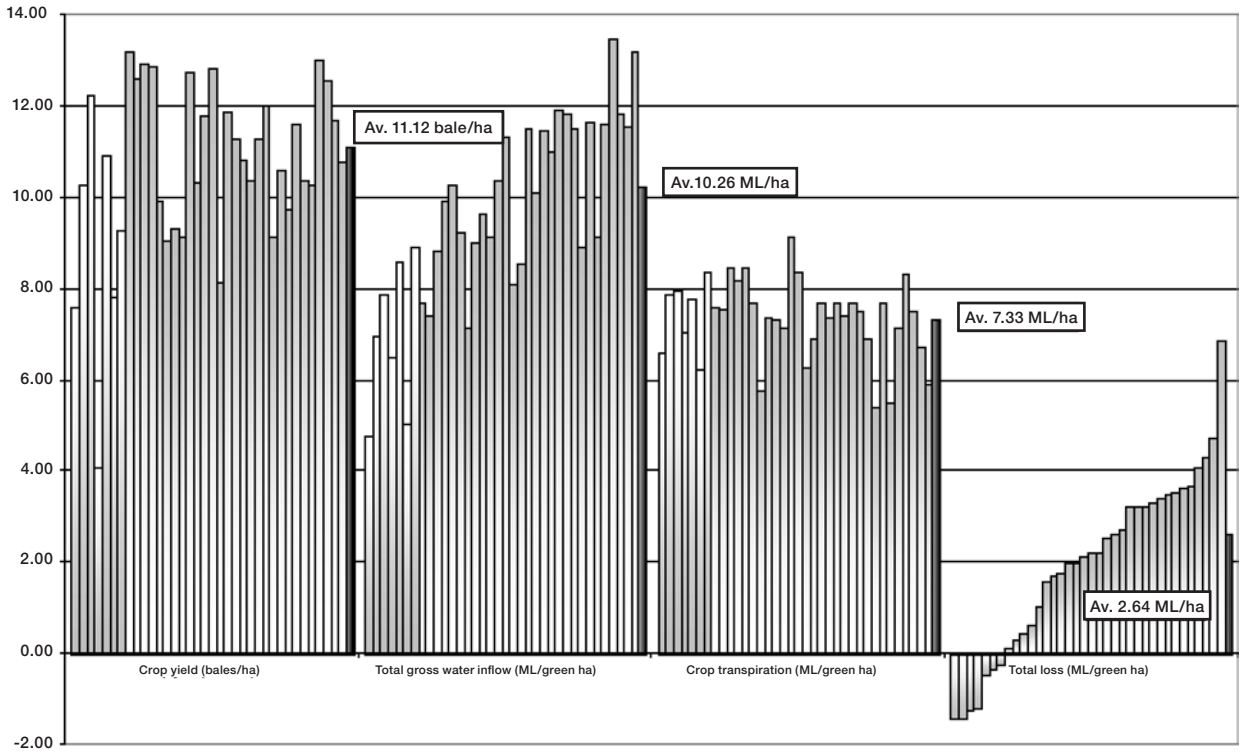


***Figure 1.*** *Variation in total (whole farm) water loss compared with yield, total gross water inflow (includes rainfall and soil water) and crop transpiration*

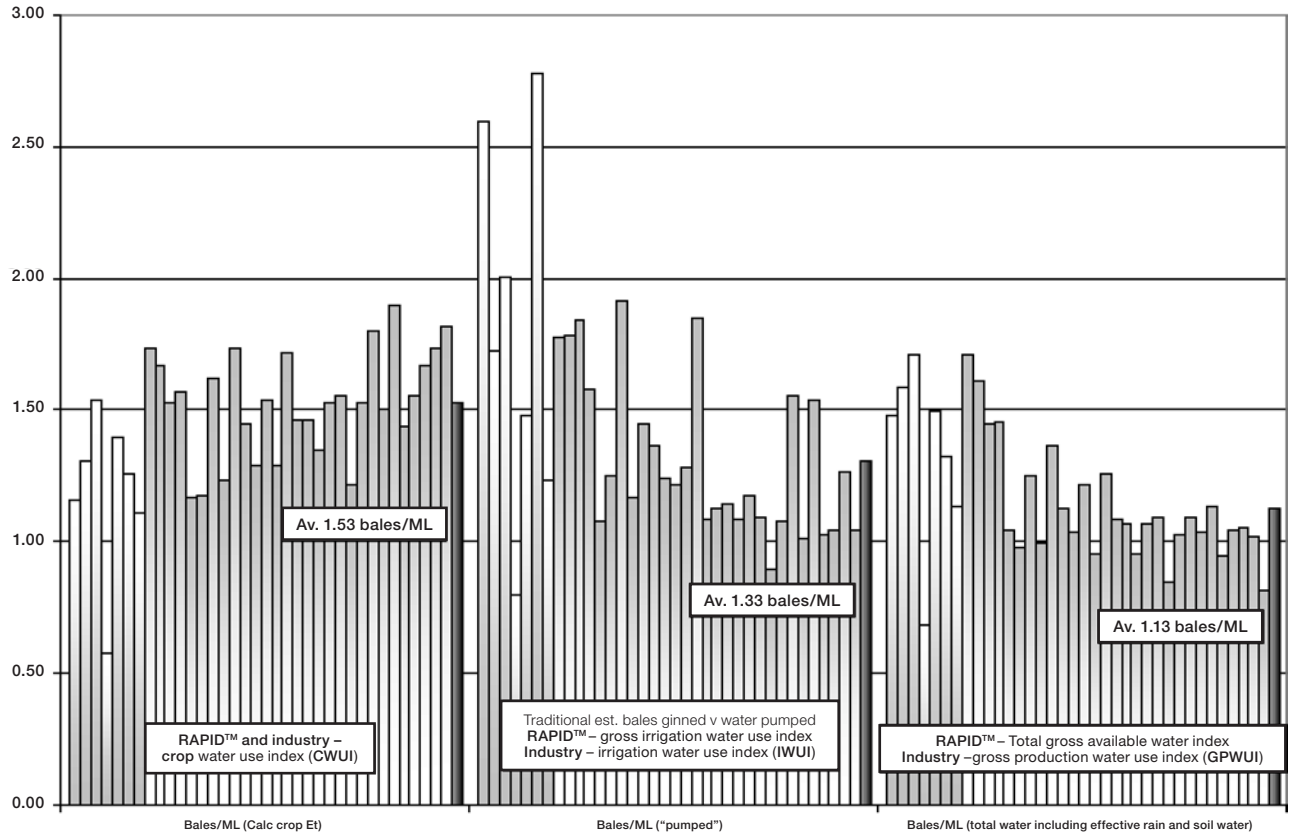


*Figure 2. Comparison of three different water use indices for cotton*

## 2. Water use indices

The water use indices used to benchmark irrigation water use are presented in Figure 2. The average CWUI was 1.53 bales/ML. The average IWUI was 1.31 bales/ML, ranging between 0.90 and 1.92 bales/ML.

A more meaningful water use index for comparing irrigation water use between farms and regions and across seasons is the **gross production water use index** (GPWUI). It is more useful than CWUI and IWUI because it relates total production to the total amount of water used – all sources, ie irrigation water, effective rainfall and soil moisture. The average GPWUI was 1.13 bales/ML, ranging between 0.82 and 1.71 bales/ML.

The significance of these results is that the collection and calculation of the water use indices has been standardised, enabling meaningful comparison between the farms surveyed.

**The average GPWUI of 1.13 bales/ML is the figure that is representative of the cotton industry water use in 2006–07.**

It is this figure that can be used to benchmark water use so industry can gauge if it is further improving and the rate of improvement over time.

A previous unrelated study in 2003 obtained production and water use data from 25 cotton farms and over 200 individual fields over three seasons, 1996–97, 1997–98 and 1998–99. They found the industry average GPWUI at this time to be 0.79 bales/ML. The data collected in this survey for 2006–07 shows a significant increase in GPWUI of around 40%.

## 3. Yield comparisons – highest 10 whole farm yields

Table 1 compares the WaterTrack Rapid results between the top 10 yielding farms and the lowest 10 yielding farms in the data set of 36 farms. On average the top 10 yielding farms produced 35% more cotton with 8% more water compared with the average of the 10 lowest yielding farms. The crop was estimated as requiring 7.88 ML/ha of water to grow. This is 13% higher than the average crop transpiration for the 10 lowest yielding farms. Total water losses were 21% lower with an average loss per farm of 1.93 ML/ha.

*Table 1. A comparison of yield and water use between the 10 highest and 10 lowest yielding cotton farms 2006–2007*

| | Highest | Lowest | % Change |
|---|---|---|---|
| Yield (bales/ha) | 12.70 | 9.44 | 35% |
| Gross water inflow (ML/ha) | 10.24 | 9.51 | 8% |
| Crop water use (ML/ha) | 7.88 | 6.96 | 13% |
| Total water losses (ML/ha) | 1.93 | 2.34 | 21% |

*Figure 3. The target gross production water use index (GPWUI) for cotton growers should be 1.39 bales/ML.*

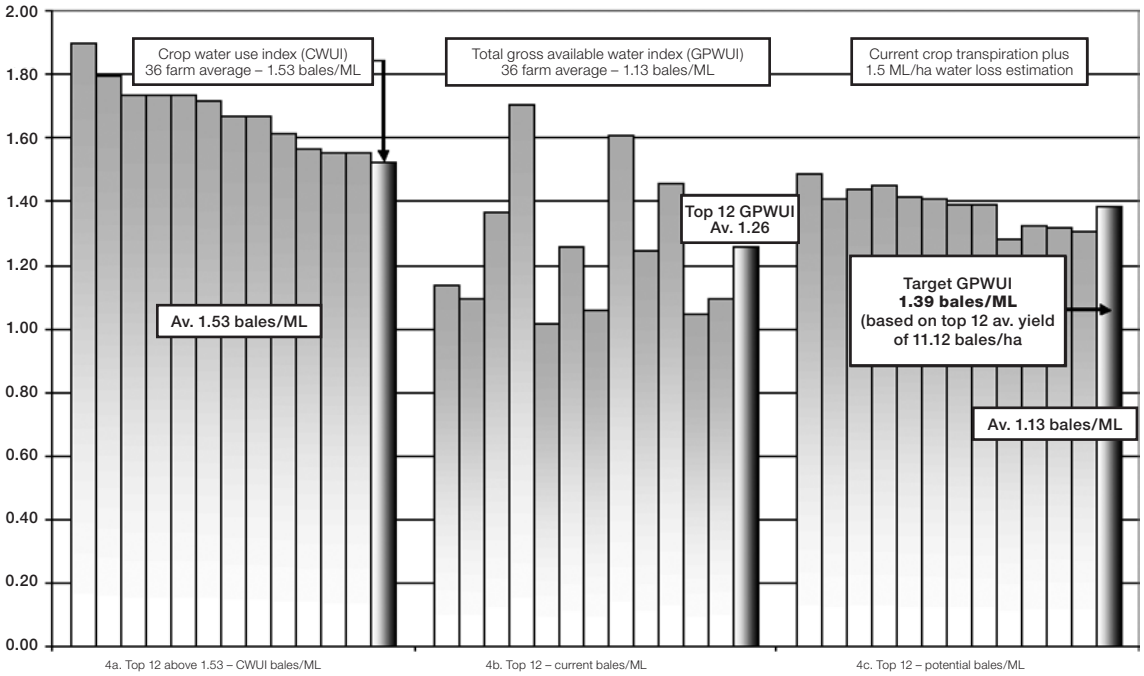


***Figure 4.*** *An estimated target GPWUI based on current best practice*

### *4. Current industry potential for bales per megalitre*

The data that was collected for the WaterTrack Rapid survey provides an interesting insight to the *potential theoretical water use indices* that can currently be achieved.

The average CWUI for all farms was 1.53 bales/ML (Figure 2). It relates yield to the crop water use ($Et_c$), not total water delivered to the farm and therefore there are no water losses taken into consideration. There were 12 farms that had a CWUI greater than 1.53 and these farms are presented in Figure 4a. We can assume that crop management on these 12 farms meets current best practice, which allowed the crop to produce more lint (bales) per ML of water consumed by the plants ($Et_c$) than the industry on average. That is, crop stress from pests, disease, or poor nutrition or water management were minimal. Therefore these farms represent the current potential to which the rest of industry can move towards.

**These 12 farms had an average GPWUI of 1.26 bales/ML (Figure 4b) compared with the average GPWUI of all farms, 1.13 bales/ML.**

***Figure 5****. David Williams said the benchmarking process was simple and quick, and enables meaningful comparisons of water use between crops, farms and regions.*

Average yield for the 12 farms was 11.12 bales/ML. Taking into account, crop water use ($Et_c$) for each farm and assuming that best irrigation practice results in a total water loss of 1.5ML/ha, Figure 4c shows the theoretical potential GPWUI for each farm.

**The average of these farms represents the industry GPWUI that growers should be targeting, which is 1.39 bales/ML.**

## Conclusions

Collecting water use data for the 2006–07 season provided a benchmark to gauge how GPWUI has improved since the 2003 attempt to estimate industry water use efficiency. The data will also be used to benchmark future comparisons of water use indices. The process was simple, quick and used a consistent approach which included rainfall and seasonal weather conditions, allowing on-farm water use to be compared across the industry. The calculation of the water use indices were standardised and defined, enabling meaningful comparison.

Determining where water is used and lost across a whole farm can be challenging. However, identifying where losses are occurring is fundamental to achieving greater farm water use efficiency. While some basic calculations are possible at the whole farm level, it can be quite difficult to partition water use and loss to different components of the irrigation system. This requires increased measurement opportunities and more accurate measurement on farm through better monitoring and the adoption of more accurate metering equipment.

### Acknowledgements

*The authors would like to acknowledge the cooperation and assistance provided by the growers and consultants who assisted with this work.*

### Further information

*Dave Williams*
*NSW Department of Primary Industries, Dubbo*
*T: 02 6881 1209*
*M: 0428 401 988*
*E: david.williams@dpi.nsw.gov.au*