2017

# Case Study Farm 4 - Cairns

Turf Queensland

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RURAL WATER USE EFFICIENCY
IRRIGATION FUTURES
Improving irrigation management for a profitable and sustainable future

# Assessing a new irrigation system and dealing with unforeseen events.

The efficient and profitable production of turf grass involves several farm management practices that directly and indirectly influence productivity, energy and water use. The introduction of precision agriculture techniques and sophisticated technologies, as well as adopting modern management practices can help to improve production.


Assessing an irrigation system and the associated management practices can help to identify any hidden issues that are affecting productivity and what options or actions can be taken to increase productivity while reducing costs. An understanding of how all factors affect production is needed to refine operating practices to obtain the most efficient production system.

This case study discusses how assessing a new irrigation system and adjusting management practices can help to maintain productivity when unforeseen catastrophic events occur and unexpected opportunity arise.

## Project outline

The project North Queensland Rural Water Use Efficiency - Irrigation Futures (NQ RWUE-IF) is a collaboration between the Queensland Government and Turf Queensland. The aim of the project was to provide training, information and support to Turf producers while assessing their farm practices and implementing alternative practices to improve water use efficiency, reduce input costs and increase productivity.

The efficiency of the irrigation system and how irrigation is scheduled are two main influencing factors of water and energy use, however other factors and management practices will also have an indirect influence on productivity and input costs. For this farm a baseline cost of producing turf under a new irrigation system was developed by assessing all farm management practices and influencing factors. The data obtained was used to develop productivity indicators and determine what options were available that could be altered or managed to increase production efficiencies. Productivity indicators used are

- Irrigation energy efficiency calculated as kilo-watts-hours per mega-litre of water pumped (kWh/ML)
- Water use efficiency measured as mega-litres of water used per hectare (ML/ha)
- Increase in yield calculated as square metres of turf per harvest ($m^2$/harvest)
- Economic benefit measured as net cost of production per square metre of turf produced ($\$/m^2$)

## Farm overview

This family owned and operated farm, located near Cairns in the wet tropics receives approximately 1900 mm of rainfall per year. Sir Walter buffalo, Zoysia, and Carpet Grass are produced on this 13.8 hectare farm. Sugar cane Mill Mud, a by-product of sugar cane crushing, is used as a soil supplement and to replenish the soil in production areas. On average two to three complete harvests per year, each taking three to four months from harvest to harvest, are achieved depending on weather conditions and market demand.

The farm had used a combination of travelling boom and hand-shift irrigators until 2015 when a new part-circle centre pivot irrigator covering 5 hectares was installed to increase production and meet market demand. Irrigation water for the whole farm is supplied by a central bore pump reconditioned in December 2014 and fitted with a variable frequency drive controller fixed to a predetermined pressure. Prior to installing the centre pivot the irrigation schedule was determined using visual inspection of the turf, daily

weather observations, the growers experience, and the time required to complete a total farm irrigation. Over several months the farm manager had been developing a new irrigation schedule to accommodate both the new centre pivot and old irrigators.

Farm management practices had been refined over the years and an assessment of the old irrigation system had been conducted but no formal evaluation of operational procedures, yield measurements or productivity indicators been developed. The time required to manage daily farm and irrigation schedules under the old irrigation system limited the time available for developing new procedures. With the installation of the new centre pivot, and participation in the RWUE project, provided the support and time to develop new management procedures, plan system upgrades and refine the irrigation schedule to suit the new operating conditions.

This process was disrupted in mid-2016 when a catastrophic power surge caused by an accident at a neighbouring property destroyed all computer systems and most electrical equipment on farm. The main irrigation pump and centre pivot irrigator was not affected due to the addition of lightening arrestors and surge protection during the centre pivot installation.

Due to the extent of the damage and the limited backup systems, a large portion of the operating information and production data was lost. During the process of replacing all electrical equipment and rebuilding databases several operational inefficiencies were identified. A decision was made to upgrade record keeping and internal communications systems by incorporating business tracking software and real-time smart communication technologies. Also due to the production efficiencies gained with the installation of the centre pivot a further decision was made to replace the remaining old irrigators with another centre pivot system to further improve production efficiencies.

These upgrades have allowed the managers to focus on more efficient management of production inputs, and irrigation scheduling. This transition to precision agriculture is an on-going process and is expected to have a greater influence on water use and energy use efficiency than expected at the beginning of the project.

## Farm assessment

The initial farm assessment was conducted between February and April 2016. The irrigation system was evaluated, irrigation water and soil samples taken for analysis, energy use and electricity tariff assessed, and daily management practices recorded. These results were used to determine the best options for the farm to improve productivity. Although these assessments were conducted prior to the major upgrades, they have been valuable with designing the new centre pivot and further refining management practices.

**Figure 1: Centre pivot irrigation with end gun on trial area.**

**Figure 2: Irrigating the newly sprigged trial area.**

### Irrigation system

The original T & L three span centre pivot with electric hydraulic drive was installed in September 2015. It has an end gun that is programmed to turn off at certain points due to the proximity of a road and another farm boundary. It is supplied irrigation water from the 15 kW Grunfos pump assembly via an underground mainline. The pump is fitted with a VFD controller set to a fixed pressure output for the old irrigator.

There were limited upgrade options available for the centre pivot due to the system being relatively new and a major reduction in

water use was not considered possible. However, the assessment identified that the coefficient of uniformity (79%) was below the industry benchmark (85%), and the flow rate from the end gun was too high. This is mainly attributed to the centre pivot operating at a higher pressure (400 kPa) than the design specifications (303 kPa).

### *Irrigation system recommendations*

Options identified to help improve application uniformity, water use efficiency, and refine an irrigation schedule include

- Install a pressure adjustment switch to adjust the operating pressure when different irrigation systems are used.
- Check end gun operating arc after the pressure reduction and adjust if required
- Incorporate the use of irrigation scheduling tools and increase awareness of irrigation management techniques.

### *Irrigation system upgrades implemented*

As there were limited upgrade options available, the three recommendations were carried out. These included

- Installing a pressure adjustment control on the pump VFD controller to change operating pressure when switching between irrigation systems.
- Adjust the end gun operating arc to improve application uniformity.
- Adjust the irrigation application rate to better suit the soil absorption rate and reduce surface pooling.

The pressure adjustment upgrade to the VFD controller will also benefit the second, newly installed, Upton three span electric drive centre pivot as each centre pivot requires at different pump pressure due to different distances from the pump.

## Energy assessment

Energy use for the centre pivot system was not measured during the original assessment due to the farm having a central power meter recording all farm electricity use. Separating electricity use for the irrigation system, office, workshop, and private residence could not be accomplished without a full energy audit or installing separate power meters.

The general use tariff 22 currently being used is appropriate for the current situation. Any energy savings attainable will be made from reducing the pumping pressure during irrigations, developing an optimum irrigation schedule to take advantage of off-peak rates, and implementing energy saving devices in all other areas of the farm and residence. If the power meter is upgraded to separate the irrigation system from the rest of farm operations, reassessment of energy use should be conducted and alternative tariffs investigated.

## Water tests

The water analysis indicate the irrigation water quality was good, slightly acidic (pH 5.6) but no major concerns for irrigating turf. All quality indicators were within acceptable levels with calcium (<1; ideal 10-120 ppm), potassium (<1; ideal 0.5-10 ppm) and iron (<0.5; ideal 2-5 ppm) considered to be below ideal concentrations.

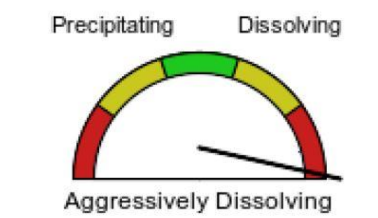


*Figure 3: indicator of irrigation water to dissolve calcium.*

Although the sodium levels were not considered an issue, the water has been identified as being very likely to dissolve calcium. This can affect calcium availability in the soil due to the sodium dissolving and displacing

the calcium from soil particles potentially causing the calcium to be leached below the root zone. Sodium levels and water quality should be monitored regularly (once or twice a year) especially during periods of drought or a noticeable change in water quality and smell. If sodium levels in the irrigation water increase quickly or double within a year a specialist should be consulted to discuss what options are available.

## Soil Tests

The soil analysis showed slight variations in soil structure and type as well as nutrient concentrations across the trial area. Two soil samples were slightly acidic with deficiencies in calcium and magnesium, with all samples deficient in the micro-nutrient boron. Sodium levels are not considered an issue, however it may be the cause of reduced calcium and magnesium concentrations in the soil profile due to the dissolving nature of the irrigation water. The addition of the 'Mill Mud' is supplementing nutrients to a degree. Further addition of calcium and magnesium is required over several months to return the soil to a nutrient balance. This will increase nutrient availability, improve soil health, and improve uniformity of turf growth throughout the year. Fertiliser type and application rates need to be determined in relation to turf nutrient requirements, the irrigation application rate, and soil infiltration rate to ensure optimum nutrient retention within the root zone for turf uptake.

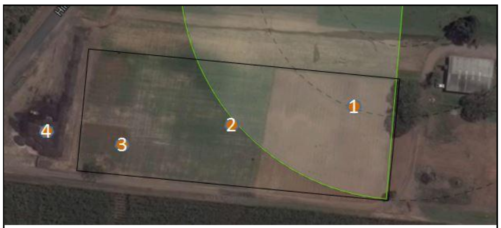
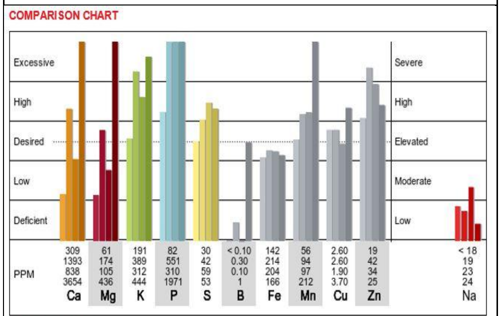



Figure 4: Location of soil samples taken within the trial area.




KEY ELEMENTS

| | IDEAL | 1 2016-01-28 | 2 2016-01-28 | 3 2016-01-28 | MILL MUD 2016-01-28 |
|---|---|---|---|---|---|
| Organic Matter (humus) | | 2.40 | 4.90 | 3.60 | 21.20 |
| pH | | 4.90 | 6.60 | 5.70 | 7.70 |
| Total Exchange Capacity | | 6.20 | 10.70 | 8.40 | 24.20 |
| Ca | 68-72% | 24.99% | 65.06% | 49.85% | 75.47% |
| Mg | 13-16% | 8.23% | 13.58% | 10.42% | 15.00% |
| K | 3-5% | 7.92% | 9.32% | 9.51% | 4.70% |
| Na | <3% | 0.88% | 0.76% | 1.18% | 0.44% |
| H | 4.50% | 47.60% | 6.45% | 23.10% | 0.00% |
| Other | 5% | 10.38% | 4.83% | 5.94% | 4.40% |

Figure 5: Comparison of soil samples indicating concentrations of main nutrients.

## Irrigation scheduling techniques

The previous irrigation scheduling had been developed over years from grower experience using visual indicators, sod strength and local weather conditions. A usual irrigation schedule consisted of four to five irrigations per week running for several hours per irrigation. The main limiting factor for irrigation was the time it took to position and setup the irrigators. In many cases this required the farm manager to spend long hours on farm monitoring irrigation and re-setting the irrigators. On many occasion due to hot dry weather and increased market demand this could stretch well into the night to ensure all turf received the required amount of irrigation. After the installation of the centre pivot, the farm manager incorporated the use of the Scheduling Irrigation Diary (SID App) and considered it a valuable guide to turf water requirements but due to the variations in the reference weather station and local conditions it was used as a guide only.

## *Irrigation scheduling recommendations*

Recommendation included

- Assess soil condition and infiltration rate and adjust irrigation volume to suit soil characteristics.
- Install a weather station on farm to monitor local weather changes to assist in irrigation scheduling.
- Incorporate the use of irrigation scheduling tools to change the focus of irrigation from a set timed base schedule to either a daily turf water use or soil moisture content method.

## *Changes implemented*

After the initial farm assessment, the use of the SID App was discussed and a Delta-T soil moisture probe was introduced with training and support provided to change the focus from a timed base irrigation schedule to a root zone soil moisture and seasonal turf water use focus. A low cost wireless weather station was installed to monitor the micro-climate of the farm and provide actual rainfall and evapotranspiration (ET) data for use with irrigation scheduling tools. Data interpretation was provided for both scheduling tools as

well as support on how managing root zone moisture can reduce water use, maintain an optimum soil moisture, and increase nutrient availability while reducing input costs.

The 'SID App' is a free phone application to help irrigators make informed decisions about when and how much to irrigate. It estimates moisture lost from the soil based on the previous rainfall and evapotranspiration trends obtained from the nearest Bureau of Meteorology (BoM) weather station, or entered by the farm manager from the on-site weather station. It uses this data to estimate the volume of irrigation required to replace moisture lost over the previous 24 hour period.

The Delta-T soil moisture probe is a handheld insertion probe that measures the percentage of moisture in the top 100 mm of the soil profile. Although turf can have a root depth greater than 300mm, discussions with turf producers suggest the top 100mm has the greatest influence on turf production. Using the Delta-T soil moisture probe provided a more accurate representation of soil moisture in real-time. Over time it can help to develop a soil moisture map and identify the soil water holding capacity (full point), wilt point, recharge point (irrigation trigger), and soil infiltration rate and help to refine the irrigation schedule for more precise root zone management.


**Figure 6: Oregon Scientific WMR89 electronic weather station.**

**Figure 7: Wind sensor and rain gauge installed two meters high with no obstructions to ensure accurate readings.**

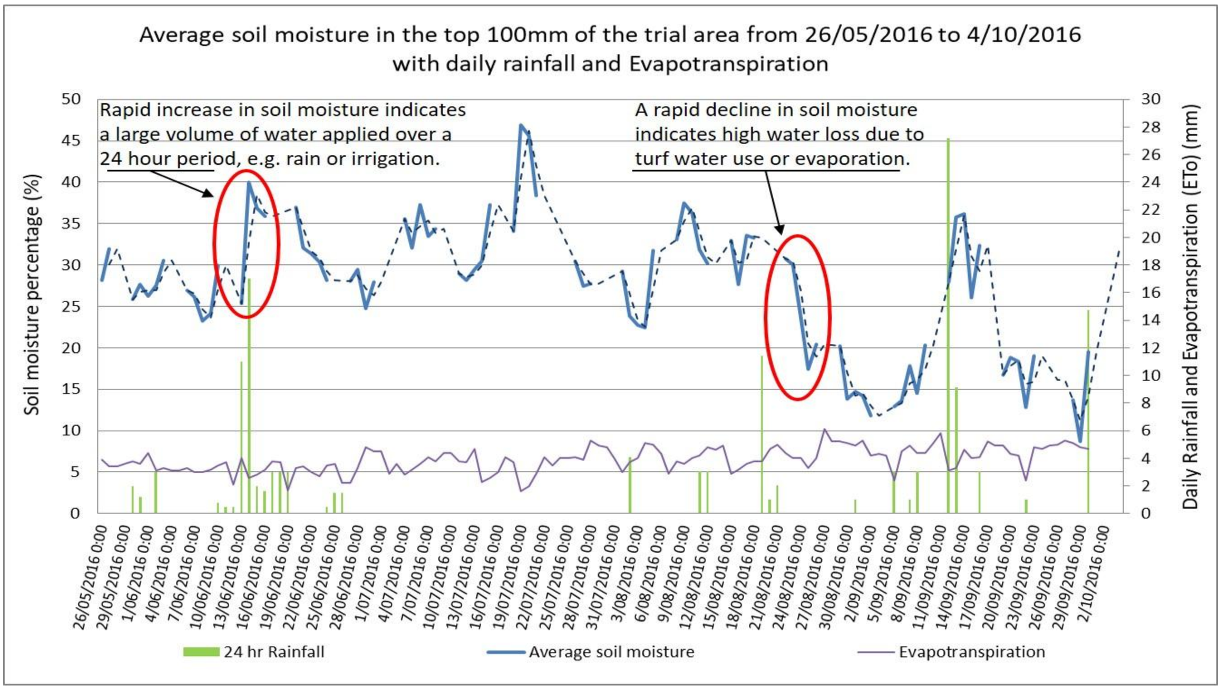



**Figure 8: An example of soil moisture in the trial area with daily rainfall and evapotranspiration data overlaid.**

## Efficiency gains and discussion of results

The efficiencies achieved for this farm are limited but highlights that even a newly installed irrigation system can be improved when production as a whole is assessed and small low cost upgrades are conducted.

### Irrigation schedule

The high rainfall experienced at this location has always interfered with using a standard timed irrigation schedule. The use of the SID App did help to refine the irrigation schedule but irrigation requirements using the SID App needed to be estimated as the rainfall and evapotranspiration (ETo) rates from the nearest BoM weather station several kilometres away in another valley did not accurately represent farm conditions. With the installation of the onsite weather station, weather condition are now monitored several times a day and the rainfall and ETo data can be input to the SID App to provide an even greater accuracy of the application. Furthermore, the 24 hour predictive forecasting function within the weather station provides another mechanism in the irrigation scheduling process.

Using the SID App and weather station in combination with the soil moisture probe has provided a greater accuracy and peace of mind in determining irrigation requirements. Data recorded with the soil moisture probe has shown that under the earlier irrigation schedule soil moisture fluctuated between approximately 22% and 47%. After changing the irrigation schedule, soil moisture fluctuated between approximately 10% and 37% without any loss of turf quality, see Figure 5. The longer periods between irrigation and rainfall events means nutrients are retained within the root zone longer. From the data analysed to date, a soil moisture range of 20% to 35% should be targeted. At the moment the soil moisture data is being used as a check mechanism but with ongoing monitoring of soil moisture in relation to rainfall and ETo an optimum soil moisture range can be determined to provide a greater control over nutrient retention and water use.

### Water use

Water use savings were limited for the new centre pivot, however a reduced of 14% or 0.39ML/Ha (weather dependent) was achieved through reducing the operating pressure of the irrigation system and changes in the irrigation schedule. Further water savings for the original centre pivot will be achieved as the irrigation schedule is refined further. Greater water savings are expected for the whole farm as the irrigation schedule for the second centre pivot is refined.

### Energy Use

Although a full assessment of energy use was not possible at the beginning of the project, the upgrades made to the irrigation pump controller, for less than $400, included a power/frequency monitor. This device indicates the kilowatts being used by the pump in real-time. Using a pressure adjustment control to increase or decrease the power frequency, the pumps output pressure can be changes to suit different irrigation systems. The data recorded at different operating pressures was used to estimate the energy use.

At the original higher operating pressure of 414 kPa (60 psi) pump energy use was recorded at 20.1 kW. After the controller upgrade, the pressure was adjusted to design specifications of 303 kPa (44 psi) and pump energy use was reduced to 6.63 kW. This equates to a yearly reduction in pump energy of 1444 kWh (41%). Pumping costs have been reduced by 59 kWh per mega-litre or $12 per mega-litre pumped. With the commissioning of the second centre pivot and identification of the optimum irrigation schedule there is potential for energy use to be reduced further.

Figure 9: Pressure adjustment and power monitor upgrade for the VFD pump controller.

Figure 10: Energy use monitor indicating pump operating frequency and kilowatt usage.

## Fertiliser use

A true comparison of fertiliser use could not be made due to the trial area being in a newly established area and the incorporating of mill mud during soil preparations. Actual fertiliser requirements will not be known until after several production/harvest cycles have been conducted. However the farm manager did state that fertiliser applications have been limited under the centre pivot due to the uniformity and quality of the turf being produced, but an application of urea was applied prior to harvest to ensure turf quality does not decline during harvest and transport.

## Harvest waste

Prior to the installation of the centre pivot the average harvest waste for the farm was 5%. Waste recorded after the first harvest of the trial area was calculated at 1.5%. This suggests harvest waste under the new irrigation system and scheduling practices will be reduced by an average of 3.5% or 92.6m$^2$ ($828) per harvest for the trial area. This equates to a 3540 m$^2$ increase in saleable turf over 2 harvests for the whole area under the centre pivot. At a cost of $8.95 per square metre this is potentially an increase in income of over $30,000 per year.

## Unexpected improvements

At the beginning of the project there was no indication that major changes would take place during the year, but an unforeseen and uncontrollable accident that was initially consider a major setback to the farm has proved to be of great benefit. These benefits include

- The forced replacement of computer equipment and a redesign of administration processes has led to a better on-farm communications system, the installation of more efficient business tracking software, and an integrated record keeping process across all aspects of turf production.
- The replacement of an old irrigation system with a more efficient centre pivot system that will increase productivity and operational efficiencies further.
- Reduced labour requirements for maintenance and irrigation management due system automation and better turf quality.

## Productivity improvements

The productivity improvements made have been due to the low cost changes made to the irrigation pump controller, refined irrigation schedule, and changes to general management practices. Greater productivity improvements are expected with the development of an irrigation schedule for the second centre pivot.

The low water savings recorded for this farm does not represent the potential water savings expected when both centre pivot systems are operating at maximum efficiency. Water use and energy use is expected to drop further due to the reduced irrigation durations and frequency required using the more efficient and uniformed centre pivot irrigators.

The upgrades and management changes undertaken during the project has resulted in a reduction of input costs of 5% and an increase in productivity of $0.07 per square meter. Turf quality has increased and waste at harvest decreased with the change in management practices. Harvest waste under the new irrigation system and scheduling practices has been reduced resulting in an increase in saleable turf of 3540 $m^2$ over 2 harvests for the whole area under the centre pivot per year. At a cost of $8.95 per square meter this effectively provides an increase in income greater than $30,000 per year. The saving made during this project has resulted in most efficiency targets being achieved (see table 1).

**Table 1: Summary of productivity improvement from the RWUEIF project.**

| ACTIVITY | TARGET | ACTUAL IMPROVEMENT |
|---|---|---|
| Water use improvement | 15% or 1ML/Ha | 14% or 0.39 ML/ha |
| Energy use improvement | 25% | 41% |
| Fertiliser use improvement | 12% | N/A |
| Productivity improvement | 10% | 30% |
| Yield (Waste reduction) improvement | 5% | 6.4% |

## Conclusion

This project has increased the knowledge and awareness of farm staff through the introduction of irrigation efficiency assessments and irrigation scheduling training. The introduction of different irrigation scheduling tools and the training provided has changed the growers' attitudes to irrigation scheduling and has led to greater changes in farm management practices.

This farm has now increased the potential to reduce water and energy use further and increase productivity with the installation of a second centre pivot irrigator and ongoing refinement of the irrigation management practices.

The implementation of business tracking software and smart communication, has an indirect influence on operational efficiency through direct communication between farm manager, field staff and administration to provide real-time updates on task completion, amount of turf available for orders, and irrigation scheduling response to changes in daily weather conditions. The installation of more efficient irrigation systems has provided a greater level of irrigation automation that allows irrigation events to be triggered during off-peak electricity time without the need of a staff member being on site after hours. These improvements have achieved efficiency gains and increased productivity while improving the managers' work-life balance. The time saved has been re-invested in monitoring operational efficiencies and developing more efficient practices.

The farm manager has commented that efficiencies recommended by this project have *'changed his management practices and led to a better quality of life due to the reduced labour and maintenance requirements compared to the previous system, and was a major contributing factor to purchasing a new centre pivot irrigation system to increase operational efficiency and productivity.'*

Acknowledgments: We would like to thank all the turf producers who participated in this project and the following people for their support and input into this case study

- David Hunt, researcher and author
- Jim Vaughan, QTPA
- Steve Attard, AgriTech Solutions
- NuTurf Solutions

**This pilot farm case study is published by Turf Queensland as part of the Rural Water Use Efficiency Irrigation Futures project delivered through collaboration with the Queensland governments Department of Natural Resources and Mines.**



**Department of Natural Resources and Mines**