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IMPROVING DAIRY IRRIGATION PRACTICES

Field day 21 May 2009

Summary of Irrigation Evaluation – Acerna Pastures, Geraldine - April 2009

Aqualinc Research Ltd completed an evaluation of this irrigation system to assess its overall performance, and to identify areas for potential improvements in efficiency. The evaluation was conducted as one component of Sustainable Farming Fund (SFF) project C07/004.

Farm Description

Size:	172 ha total (150 ha evaluated)
Irrigation:	2x full-circle centre-pivots (120 ha)
	Long-lateral sprinklers (20 ha)
Water:	Buried gallery next to Hae Hae Te Moana River
	Consented 30,085 m^3/week (50 ℓ/s continuous, 61 ℓ/s maximum rate)
	Frequently subject to restrictions in second half of irrigation season
Soils:	Variety of silt loams, generally lighter to the North
	Plant Available Water (PAW) ranges 50 ~ 150 mm/m (~80% is 150 mm/m)
Pasture:	Arrow perennial / Bealey ryegrass
Supplement:	300 kg silage per cow, mostly made off platform
Cows in milk:	715 in 2008
Milk solids:	1,540 kg / ha in 2008

Pressures and Flow Rates

Pressure and flow rate measurements taken throughout the system indicate that the pumps are performing to specification and the southern centre-pivot was receiving adequate pressure. However, due to several leaks in the northern half of the system (in a buried pipe supplying long lateral sprinklers and at the joint between the first and second spans of the northern centre-pivot), the northern centre-pivot was operating well below its specified pressure.

System Capacity

Water use KPI	Northern Centre-Pivot	Southern Centre-Pivot
Irrigated Area (ha)	78	52
Assumed crop demand (mm/day)	4.0	4.0
Specified capacity (mm/day)	3.7	3.5
Measured capacity (mm/day)	3.4	2.7
Effective capacity (mm/day)	3.2 *	2.5 **
Measured Application depth (mm)	10	7.5
Return interval (days)	2.8^{+}	2.2^{+}

Note: Capacities are based on flow rates and areas when all corner arms and end guns are operating.

* Effective = Measured capacity x Typical centre-pivot application efficiency (94%)

** Effective = Measured capacity x Measured application efficiency (93%)

$^{+}$ Based on measured machine travel speed, and assumes 24-hour, 7-day/week operation.

Both of the centre-pivots were operating at less than the estimated crop demand of 4.0 mm/day. This means that the system is not expected to be able to keep up during the dryer months, and some plant stress is likely to occur. If no additional water can be secured, careful management of soil moisture will be critical to maximising production. Irrigation scheduling should be based on measured soil moisture. This can help with the efficient execution of strategies such as increasing soil moisture prior to the drier part of the season to avoid plant stress at times when the system may not be able to keep up with evapotranspiration.

Application Rate

Some minor ponding was observed under both of the centre-pivot irrigators, indicating an application rate exceeding the infiltration rate of the soil (~40 to 60 mm/hr). However, this is believed to be due to the fact that the evaluation was conducted on a day that irrigation would not normally have occurred due to high soil moisture levels. Ponding is not expected to be a regular problem on this property.

Application Uniformity

Measured application uniformity under the southern centre-pivot fell within the recommended range for a typical centre-pivot system (see table below). This is a good result and means that water is being applied evenly across each paddock.

Southern centre-pivot uniformity	Measured	Recommended Minimum Values
Average Application Uniformity (DU_{lq})	76 %	76 – 82 % *
Average Application Uniformity (CU_c)	87 %	85 – 90 % *
Potential application efficiency	93 %	93 – 95 % *

* Based on recommended uniformities reported in INZ's Design CoP.

While it fell within the recommended range, there may be ways to further improve application uniformity. For example, an increased application depth could potentially achieve this. Because application depth is low (9 mm) small variations along the pivot spans will result in relatively large variation (%) in applied depth. By increasing the application depth, these small variations become less important overall, and uniformity is increased. It is believed that these soils have enough capacity to hold at least 25 mm of readily available water, meaning that application depths of up to 25 mm may be used on dry soils without causing excess drainage.

However, increased application depth means an increase in instantaneous application rate, and careful monitoring for ponding and runoff will be necessary. If ponding or runoff are observed, application depth (and therefore application rate) may need to be decreased.

Energy Efficiency

The total energy rating (kW) of this system is similar to what would be theoretically expected, based on the measured pressure and flow rate at the pump.

Energy KPI		Measured	Theoretical / Typical Values
System energy rating	(kW)	38	39
	(kW / ha)	0.25	0.26
Surface pump efficiency	(%)	72	70
Energy per unit volume	(kWh / 1000 m^3)	180	170

Labour Efficiency

There is not much room for improvement in labour efficiency for these types of irrigation.

Labour KPI		Centre-pivots	Long laterals	System Total
Total labour required	(hrs/day)	0.1	0.5	0.6
	(hrs/ha/yr)	0.1	3.8	0.6
	(hrs/1000 m^3)	> 0.0 *	1.2 *	0.1

* Based on estimated flow rates based on the in-line flow meter, installed at the pump shed.

Operating Costs

Energy costs for pumping account for more than 80% of irrigation operating costs on this farm, which serves to highlight the potential savings to be made by reducing energy consumption. The pumping costs calculated for this farm are generally comparable to costs calculated in a previous Aqualinc study (McIndoe 2003) for water sources at a similar depth.

Operating cost KPI	Centre-Pivots	Long Lateral Sprinklers	System Total
Energy cost per hectare ($/ha/yr)	$95*	$95*	$95
Labour cost for operation ($/ha/yr)	$0	$110	$15
Labour cost for maintenance ($/ha/yr)	> $0	> $0	> $0
Motor bike operation ($/ha/yr)	$0	$40	$5
Total operating cost per hectare ($/ha/yr)	$95	$245	$115
Energy cost per volume ($/1000 m^3)	$25*	$25*	$25
Labour cost for operation ($/1000 m^3)	$0	$35	$5
Labour cost for maintenance ($/1000 m^3)	> $0	> $0	> $0
Motor bike operation ($/1000 m^3)	$0	$10	> $0
Total operating cost per volume ($/1000 m^3)	$25	$70	$30

Note: All calculated values rounded to the nearest $5.

* Could not separate energy costs for different systems because all operate from same pumps.

Other Notes

There is currently no way to monitor the performance of the submersible pump installed in the gallery. Installation of pressure gauges at the outlet of the submersible pump (or inlet to the surface pump) would allow for its monitoring, and would provide a check for adequate pressure for efficient operation of the surface pump. A periodic record of gallery water levels and pump pressure would provide enough information to check that the pump and gallery are both continuing to perform to specification as time goes on.

The reliability of water supply is a big issue on this property. It has been brought to our attention that restrictions (allowing 50% flow rate) may be experienced for 30 days in a row in a dry season. This has the potential to hugely limit farm productivity, and any investment in strategies to improve the reliability of supply (such as installing a storage pond) are likely to lead to significant payoff.

Key Points

- Leaks in the system (a pipe supplying one of the long lateral sprinklers, and the joint between the first and second spans of the northern centre-pivot) are causing reduced performance.

- The variable speed drive (VSD) helps to reduce the energy consumption of the 45 kW motor down to 29 kW without moving too far away from the maximum efficiency point. However, energy costs for pumping account for more than 80% of irrigation operating costs on this farm, which serves to highlight the potential savings to be made by any further reduction in energy consumption.

- Both of the centre-pivots were operating at less than the estimated crop demand of 4.0 mm/day. This means that the system is not expected to be able to keep up during the dryer months, and some plant stress is likely to occur. If no additional water can be secured, careful management of soil moisture will be critical to maximising production.

- While measured application uniformity under the southern centre-pivot fell within the range recommended in INZ's CoP, there is potential for further improvement. More efficient application of water increases the amount of water that reaches (and therefore is taken up by) the plants, thus improving production. Maximising application uniformity is especially important because the designed capacity of the system is less than the theoretical crop demand of 4.0 mm/day.

- There is currently no way to easily monitor the performance of the submersible pump installed in the gallery. The performance of this pump is just as important to the overall performance of the system as the main, surface pump.

Potential system changes and their costs / benefits (as identified by system evaluation)

	Benefit	**Cost**
Repair leaks as soon as discovered	Reduce wasted water, and maximise system performance	No cost, repairs just happen sooner
Increase system capacity (75 ℓ/s needed for *effective* 4.0 mm/day)	Potential to meet peak crop demand = increased production ≈ $275 / ha / yr * + possible increase in reliability	One-off cost of additional water + Annual water cost ≈ $255 / ha / yr * (annualised over 10 yrs)
Try increasing application depth under centre-pivots	Potential increase in application uniformity = increased production	No cost. Just monitor for ponding/runoff
Install pressure gauges at outlet of gallery pump and/or inlet of surface pump	Allow check/record of pump and gallery performance = quicker identification of problems	Approx. $100

* Estimates from Nicky Hyslop, based on OWL charges and production estimates (see insert for details).

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