IMPROVING DAIRY IRRIGATION PRACTICES

Field day 22 April 2009

Summary of Irrigation Evaluation – Roel & Diana Wobben, Rangiora - February 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. Only the ***Home Block*** and ***Over-road block*** were considered in this evaluation.

Farm Description

Size:	530 hectare (effective)
Irrigation:	Home Block (310 ha) = Centre-pivot (275 ha) + Long Laterals (35 ha)
	Over-road Block = Hard-hose Gun (105 ha)
	B-Block (88 ha) = Half-pivot (38 ha) + Roto-Rainer (41 ha) + K-Lines (4 ha) + Long Laterals (5 ha)
Water:	Waimakariri Irrigation scheme (300 ℓ/s)
	Groundwater (active, 30 ℓ/s)
	Groundwater (backup supply, 120 ℓ/s)
Soils:	Lismore stony silt loam (Plant Available Water of ~60 mm/m)
Pasture:	Perennial ryegrass
Supplement:	1000 kg DM/cow + 500 kg grain/cow
Cows in milk:	600-700 (summer), 450 (winter)
Milk solids:	1,600 kg / ha

Pressures and Flow Rates

Pressure and flow rate measurements made throughout the system indicate that the main pump station is performing to specification, and that the large centre-pivot irrigator is receiving sufficient pressure and flow. However, there is some room for improvement in the performance of the long lateral and hard hose gun systems, which were each found to be performing 10% below the recommended pumping efficiency.

System Capacity

	Large Centre-Pivot	Hard-hose Gun
Peak crop demand (mm/day)	5.0	5.0
Measured capacity (mm/day)	5.7	4.4
Effective capacity (mm/day)	5.2 *	3.9 *
Application depth (mm)	23 **	31
Return interval (days)	3.5	9

* Effective = Measured capacity x Measured application efficiency

** Discrepancy between measured system capacity/return interval and measured application depth, attributed to increased flow rate through main span sprinklers as corner arm folds in.

The large centre-pivot is able to keep up with the assumed peak crop demand of 5.0 mm/day. The measured application depth and return interval match the soil properties well.
The hard hose gun system is not able to keep up with crop demand during the driest months (5 mm/day), and some plant stress is likely to occur. The measured application depth matches the soil water holding capacity relatively well. However, the return interval of 9 days is too long, and crop stress is likely to occur, especially during times of peak crop demand.

Application Rate

Ponding and surface runoff were observed under the corner arm of the large centre-pivot, which was partially retracted at the time of the test evaluation, indicating an application rate exceeding the infiltration rate of the soil. There is potential to improve water use efficiency by reducing the flow rate into the corner arm in the areas between corners, when the arm is folded in.

Little to no surface ponding was observed under the hard hose gun irrigator, indicating an effective application rate, appropriate to the soil type.

Application Uniformity

Measured application uniformity under the large centre-pivot fell below the recommended range. This low uniformity can be attributed, at least in part, to the many broken sprinklers noted during the evaluation, and to the over-application under the partially retracted corner arm.

Large centre-pivot uniformity	Measured	Recommended Minimum Values
Average Application Uniformity (DU_{lq})	74 %	76 – 82 % *
Average Application Uniformity (CU_c)	83 %	85 – 90 % *
Potential application efficiency	92 %	93 – 95 % *

* Based on recommended uniformities for a centre-pivot irrigator, reported in INZ's Design CoP.

Measured application uniformity under the hard hose gun is considered to be adequate, but on the low end of the recommended range. Hard hose guns are greatly affected by high winds, which are common in the North Canterbury region.

Hard-hose gun uniformity	Measured	Recommended Minimum Values
Average application uniformity (DU_{lq})	62 %	60 – 76 % *
Average application uniformity (CU_c)	76 %	75 – 85 % *
Potential application efficiency	88 %	88 – 93 % *

* Based on recommended uniformities for a travelling gun irrigator, reported in INZ's Design CoP.

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 pumps.

		Hard Hose Gun	Large Centre-pivot	Long Lateral Sprinklers	System Total
Energy rating	(kW)	80	135	20	237
	(kW / ha)	0.75	0.49	0.65	0.53
	(kWh / 1000 m^3)	420	210	360	265

Labour Efficiency

There is not much room for improvement in labour efficiency for the types of irrigation evaluated on this property.

		Hard Hose Gun	Large Centre-Pivot	Long Lateral Sprinklers	System Total
Labour for operation	(hrs/day)	2	0	1	3
Labour for maintenance	(hrs/month)	2	2	2	6
Total labour required	(hrs/day)	2.1	0.1	1.1	3.2
	(hrs/ha/yr)	3.0	> 0	4.6	1.1
	(hrs/1,000 m^3)	0.5	> 0	0.9	0.2

Operating Costs

Energy costs for pumping account for approximately 80% of irrigation operating costs on this farm, which serves to highlight the potential savings to be made by any reduction in energy consumption.

	Hard Hose Gun	Large Centre-Pivot	Long Lateral Sprinklers	System Total
Energy cost per hectare ($/ha/yr)	$435	$250	$360	$300
Labour cost for operation ($/ha/yr)	$85	$0	$130	$30
Labour cost for maintenance ($/ha/yr)	$5	> $0	$10	> $0
Motor bike or Tractor operation ($/ha/yr)	$140	$0	$45	$40
Total operating cost per hectare ($/ha/yr)	$665	$250	$545	$370
Energy cost per volume ($/1000 m^3)	$80	$40	$70	$50
Labour cost for operation ($/1000 m^3)	$15	$0	$25	$5
Labour cost for maintenance ($/1000 m^3)	> $0	> $0	> $0	> $0
Motor bike or Tractor operation ($/1000 m^3)	$25	$0	$5	$10
Total operating cost per volume ($/1000 m^3)	$120	$45	$100	$65

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

Other Notes

The biggest impediment to effective irrigation on this property is the reliability of the WIL irrigation scheme. While the "backup supply" of groundwater can keep the centre-pivot and hard hose gun systems running at full capacity at up to 50% WIL scheme restriction, a full restriction means that only approximately 65% of the peak crop demand will be met under the large centre-pivot, and no water will be available to the hard hose gun system.

Key Points

- Overall, the irrigation systems seem to be well suited to the property. When the Waimakariri Irrigation Ltd irrigation scheme is operational, this farm has the capacity to keep up with most of the theoretical peak crop demand of 5 mm/day, and there is little observed surface runoff, even under most parts of the long centre-pivot.

- The system pumps are performing reasonably well, and supply water to the irrigators at a sufficient pressure and flow rate. However, the hard hose gun and long lateral pump in systems are operating approximately 10% lower than the recommended efficiency. Further investigation into the cause of the relatively low efficiency is warranted. More efficient pumps are likely to lead to significant savings in energy costs.

- Ponding and surface runoff were observed under the corner arm of the large centre-pivot, which was partially retracted at the time of the test evaluation, indicating an application rate exceeding the infiltration rate of the soil. There is potential to improve water use efficiency by reducing the flow rate into the corner arm in the areas between corners, when the arm is folded in.

- Measured application uniformity under the large centre-pivot fell below the recommended range. This low uniformity can be attributed, at least in part, to the many broken sprinklers noted during the evaluation, and to the over-application under the partially retracted corner arm.

- Energy costs for pumping account for approximately 80% of irrigation operating costs on this farm, which serves to highlight the potential savings to be made by any improvement in pumping efficiency, or reduction in total energy consumption.

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

	Benefit	Cost
Improve efficiency of hard hose gun pump by 10%	Save 8 kW ($30/day ≈ $4,500/yr)	Troubleshoot / Repair (if possible), set VSD to lower pressure, or Replace pump & motor ≈ $45,000
Improve efficiency of long lateral pump by 10%	Save 2 kW ($7.50/day ≈ $1,100/yr)	One-time cost of efficient pump and motor (approx. $15,000)
Adjust flow rate to corner arm to reduce ponding and runoff	Less ponding and runoff = less pumping & less wasted water	Time taken to make adjustment
Regularly fix broken centre-pivot sprinklers	Increased uniformity (DU & CU) = Increased pasture production	Cost of sprinklers (approx. $50 /sprinkler)

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