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IMPROVING DAIRY IRRIGATION PRACTICES

Field day 21 April 2009

Summary of Irrigation Evaluation – Mark & Devon Slee, Ealing - 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.

Farm Description

Size:	340 ha total (300 ha evaluated)
Irrigation:	Full-circle centre-pivot (72 ha)
	Full-circle centre-pivot (120 ha)
	Half-circle centre-pivot (73 ha)
	K-Line (35 ha)
Water:	267 ha contracted with Mayfield-Hinds scheme (230 ℓ/s, 80 hrs/wk)
	Groundwater (three bores, using 60 ℓ/s)
Soils:	Lismore stony silt loam (Plant Available Water of ~50 mm/m)
Pasture:	Perennial ryegrass, white clover
Supplement:	303kg DM (wheat/ silage) per cow (to 18 April 2009)
Cows in milk:	850 (peak numbers)
Milk solids:	1,486 kg / ha (to 18 April 2009)

Pressures and Flow Rates

Pressure and flow rate measurements made throughout the system indicate that, overall, the pumps are performing adequately, and that the irrigators are receiving enough pressure. Although, there is some room for improving pumping efficiency. For example, one of the groundwater pumps is capable of pumping more water than the well can produce, thus requiring it to be throttled back, and forcing it to operate below its optimum efficiency point. Installing a more appropriately sized pump could theoretically result in a 4 kW ($9.50/day, or $1,400/yr) reduction in power use. Even higher efficiency gains are possible with more efficient pumping systems.

System Capacity

	East Centre-Pivot	Northwest Centre-Pivot	Southwest Centre-Pivot	K-Line
Peak crop demand (mm/day)	5.0	5.0	5.0	5.0
Measured capacity (mm/day)	4.6	4.0	5.7	4.6
Effective capacity (mm/day)	4.3*	3.2 **	4.6 **	3.4*
Application depth (mm)	18	***	***	~~24~~ 48
Return interval (days)	3.9	***	***	8 - 14

* Effective = Measured capacity x Measured application efficiency
** Effective = Measured capacity x Typical centre-pivot application efficiency
*** Not measured as part of this study

Because the effective system capacities are lower than peak crop demand under all irrigators, this system will not be able to keep up during the driest months. Some plant stress will occur during these periods, especially under the northwest centre-pivot and K-Line.

Shifting the K-Lines twice per day is likely to help pasture production, by decreasing the return interval, which is currently far too long (up to 14 days in some paddocks) to avoid significant crop stress, even during times of relatively moderate evapotranspiration.

Application Rate

Very little surface ponding was observed on this property, indicating effective application rates that do not exceed the infiltration rate of the soil.

Application Uniformity

Measured application uniformity under the eastern centre-pivot falls 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.

Centre-pivot uniformity	Measured	Recommended Minimum Values
Average Application Uniformity (DU_{lq})	79 %	76 – 82 % *
Average Application Uniformity (CU_c)	88 %	85 – 90 % *
Potential application efficiency	94 %	93 – 95 % *

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

Measured application uniformity under the K-Line is very low, when compared to the recommended minimum values (see table below). This means that water is not being applied evenly across the K-Line paddocks and many areas are being under- or over-watered.

K-Line uniformity	Measured	Recommended Minimum Values
Average Application Uniformity (DU_{lq})	30 %	68 – 76 % *
Average Application Uniformity (CU_c)	50 %	80 – 85 % *
Potential application efficiency	75 %	90 – 93 % *

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

Varying the K-Line shifting regime is likely to increase uniformity. Instead of placing K-Lines in the same location on every rotation (same 18 metre spacing), placing K-Lines 9 metres from where they were located on the last round will help fill in gaps left by the (too wide, 18 metre) current spacing, without having to increase the return interval by adding additional shifts.

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.

Because surface pumps do not have to move water from as great a depth as submersible pumps, they require significantly less energy to irrigate a similar area. This becomes evident when comparing the energy ratings of the irrigators supplied from groundwater to those supplied by surface water (see table below). On this farm, the systems supplied by groundwater require 2-3 times more energy to move the same amount of water (kW/ha, kW/1000 m^3).

	East Pivot	Northwest Pivot	Southwest Pivot	K-Line	System Total
Water source *	GW	SW	SW	GW	-
Energy rating (kW)	66	24	45	24	159
(kW / ha)	0.9	0.3	0.4	0.7	0.5
(kWh / 1000 m^3)	460	200	155	350	255

* GW = groundwater, SW = surface water

Labour Efficiency

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

	Centre-Pivots	K-Line	System Total
Labour for operation (hr/day)	0.0	1.0	1.0
Labour for maintenance (hr/month) *	2.0	2.0	4.0
Total labour required (hr/day)	0.1	1.2	1.3
(hr/ha/yr)	> 0.0	5.3	0.7
(hr/1000 m^3)	> 0.0	0.9	0.1

* Assumed 2 hr/month routine maintenance for K-Line, and 2 hr/month for all three centre-pivots.

Operating Costs

	East Pivot	North-west Pivot	South-west Pivot	K-Line	System Total
Energy ($/ha/yr)	$340	$125	$140	$320	$195
Labour for operation ($/ha/yr)	$0	$0	$0	$150	$20
Labour for maintenance ($/ha/yr) *	> $0	> $0	> $0	$10	> $0
Motor bike operation ($/ha/yr)	$0	$0	$0	$55	$5
Total operating cost ($/ha/yr)	$340	$125	$140	$535	$220
Energy ($/1000 m^3)	$60	$25	$20	$55	$30
Labour for operation ($/1000 m^3)	$0	$0	$0	$25	$5
Labour for maintenance ($/1000 m^3) *	> $0	> $0	> $0	> $0	> $0
Motor bike operation ($/1000 m^3)	$0	$0	$0	$10	> $0
Total operating cost ($/1000 m^3)	$60	$25	$20	$90	$35

Note: All calculated values rounded to the nearest $5.
* Assumed 2 hr/month routine maintenance for K-Line, and 2 hr/month for all three centre-pivots.

Energy costs for pumping account for more than 85% 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.

Other Notes

There is currently no way to monitor flow rate into the northwest or southwest centre-pivots. Flow meter readings are essential to the calculation of many of the KPIs discussed in this report, so a working flow meter is a "must" for ongoing performance checks. Monitoring flow rate and volume can also help identify other performance problems such as leaks, or declining pump performance.

Key Points

- The pump in bore K37/1408 is operating below the recommended efficiency rating. This means that it is using more energy than a pump of its size should be using to provide the measured pump load. This pump is throttled back (valve partially closed) to keep from pumping the well dry. Increasing the efficiency of this pump to the recommended efficiency would theoretically result in a 4 kW ($9.50/day, or $1,400/yr) reduction in power use.

- The northwest centre-pivot pump is also operating below the recommended efficiency rating. The VSD on this pump was throttled back significantly, thus moving the pump away from its optimum efficiency point. Increasing the efficiency of this pump to the recommended efficiency would theoretically result in a 1 kW ($2.50/day, or $375/yr) reduction in power use.

- Given the site soil's water holding capacity, the current K-Line return interval is too long to avoid depletion of soil water content to a level below the management allowable deficit (MAD). Shifting twice per day will help reduce this return interval, but will require more labour.

- The K-Line do not meet INZ's recommended application uniformity for a typical K-Line system. At least some of this low measured uniformity may be attributed to the relatively wide shift spacing. Shifting into the gaps will help increase uniformity.

- Energy costs for pumping account for more than 85% of irrigation operating costs on this farm. Reductions in energy consumption are likely to lead to greater cost savings than any other efficiency gain.

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

	Benefit	Cost
Improve efficiency of pump in K37/1408 (by replacement)	Save 4 kW ($9.50/day, or $1,400/yr)	One-time cost of efficient pump and VSD (approx. $20,000)
Improve efficiency of northwest pivot pump (by VSD adjustment or pump replacement)	Save 1 kW ($2.50/day, or $375/yr)	One-time cost for new pump (approx. $7,000)
Obtain more surface water and save groundwater as 'backup supply'	Increase system capacity, and save ~$200/ha/yr (pumping surface water is more efficient)	Cost of surface water shares (one-time cost of $3,400 / ha)
Shift K-Line twice per day (reduce return interval to 4-7 days)	Avoid pasture drying out during long periods of no water	Additional 1 hr/day of labour ($30/day, $4,500/yr)
Shift K-Line into the gaps (increase application uniformity)	Improve pasture quality	Train staff to shift differently

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