IRRIGATION
NEW ZEALAND
TECHNICAL & TRADE

CASE STUDY 1:

CANTERBURY DAIRY FARM

Summary

Using the Irrigation Decision Support Package to assist with obtaining quotes and design input may have lead to:

- better project cost estimates and avoidance of overruns ($1,000/ha);
- lower on-going operating costs (e.g. reduce electricity cost per year by $3,000-6,000), and;
- more efficient water application (i.e. more production and less water used).

EECA BUSINESS

meridian

About this Property

This 200 ha property is located adjacent to a large river in South Canterbury. The farm's primary business is grazing non-milking cows in support of local dairy operations.

The soil type varies considerably across this property. There are several terraces, with light stony soils on the lowest terrace near the river, and deeper heavier soils on the upper terraces. Each of the soils requires a different irrigation strategy to achieve maximum production.

The majority of the property is irrigated using four centre-pivot irrigators, covering a total of approximately 150 ha. An additional 50 ha of land is irrigated using K-Line pods. Irrigation water is drawn from the river, via a small storage pond.

Irrigation Requirements

Planning irrigation for this property was complex because of the range of soil types, the terraced topography, and the irregular shape of the property caused by its proximity to the river. Table 1 summarises the irrigation requirements for this property.

TABLE 1: CENTRE-PIVOT SPECIFICATIONS		
PERFORMANCE INDICATOR	UNIT(S)	SPECIFICATION
System capacity	mm/day	4.5
Application depth (range)	mm	5-15
Return interval	days	1-3
Application intensity	mm/hr	≤ 20

The topography, soils, and shape of the property determined the types and locations of irrigation that could be used. Centre-pivots were the preferred choice of the property owner because of their high level of automation and ability to apply low application depths.

A system capacity of 4.5 mm/day was chosen to match the typical evapotranspiration (ET) for the summer months in this area.

The application depth and return interval were chosen to match the lightest soils. Lighter soils cannot hold as much water and will dry out more rapidly. Therefore, they require small application depths and short return intervals to maintain adequate soil moisture content.

Conversely, the application intensity was chosen to match the heavier soil. Water does not infiltrate as quickly into heavier soil, so water must be applied more gently.

The Development Process

The owners approached three irrigation companies, asking them each to design and quote on a new irrigation system for the property. They received three quotes, each quite different. Each designer proposed a different irrigator layout, different levels of performance, and presented their estimated costs in a different format (and using different currency exchange rates!). This made it very difficult for the property owner to compare the proposals and to decide which was most suitable.

The property owner eventually decided to hire a third-party consultant to sort out the proposals and to help them make their decision. The consultants drafted more specific requirements for the designers to work with, and requested new quotes.

Three quarters of the property could be irrigated by centre-pivots. K-Line was chosen for the remainder of the property because of its ability to be operated on difficult terrain and irregularly shaped parcels.

The system was installed the following winter, but not without some significant cost overruns. The irrigation equipment cost $100,000 ($500/ha) more than the initial quote, primarily due to time delays during which the currency exchange rate fluctuated significantly ($US0.75 to US$0.62). Earthwork costs were also approximately $100,000 more than expected. This was due to a poor initial estimate.

Measured Performance

A performance evaluation was carried out shortly after the irrigation system was installed. Table 2 summarises some of the key results of the evaluation. Table 3 is included to help interpret the uniformity values in Table 2.

TABLE 2: SUMMARY RESULTS OF KEY IRRIGATION PERFORMANCE INDICATORS						
PERFORMANCE INDICATOR	UNIT(S)	CENTRE-PIVOT 1	CENTRE-PIVOT 2	CENTRE-PIVOT 3	CENTRE-PIVOT 4	K-LINE
IRRIGATED AREAS						
EFFECTIVE IRRIGATED AREA	ha	46	52	24	28	50
SYSTEM PERFORMANCE						
SYSTEM CAPACITY	mm/day	4.3	4.5	4.6	4.8	4.5
FLOW RATE	ℓ/s	23	27	13	16	26
APPLICATION DEPTH	mm/pass	4.3	5.4	3.7	4.3	31.5
RETURN INTERVAL	days	1.0	1.2	0.8	0.9	7
HYDRAULIC PERFORMANCE						
APPLICATION INTENSITY	mm/h	21.2	23.5	12.9	9.5	1.3
APPLICATION UNIFORMITY	DU_{lq}	0.79	0.76	0.82	0.77	0.52

TABLE 3: INTERPRETATION OF APPLICATION UNIFORMITY RESULTS.					
RESULT	PERFECT	EXCELLENT	GOOD	FAIR	POOR
DU_{lq}	1.00	0.99 - 0.90	0.90 - 0.80	0.80 - 0.70	0.70 - less

Overall, the system matched the owner-specified requirements relatively well. Measured system capacity was within ±10% of the design. Application depth and intensity were low under the centre-pivots, in line with the requirements of the soils.

However, some important aspects were not specified, such as application uniformity and pumping efficiency. The system performance in these areas was found to be lacking.

Application uniformity was slightly lower than expected under the centre-pivots. Measured uniformity ranged from DUlq=0.76-0.82, where DUlq≥0.85 should be expected of a new centre-pivot. Measured uniformity under the K-Line was very poor. This means that the water being applied was not used as well as it could have been. This often leads to one of two things:

1. PRODUCTION SUFFERS
Non-uniformity means that some areas receive too little water, while other areas receive too much. Plant growth suffers as a consequence.

2. MORE WATER AND ENERGY ARE USED
Because the applied water is less effective at low application uniformities, more water would have to be applied to maximise production. This means higher cost for pumping.

Pumping efficiency (pump + motor) was measured at 62%. This is a low efficiency for a new pumping system, and means that energy was being wasted. A pumping system with an efficiency of 70-75% would have used an estimated 7-13 kW less electricity to do the same job as this system. This equates to approximately $3,000-6,000 each year in electricity.

One potential contributor to the low pump efficiency is pump cavitation. Cavitation could be caused by the low water levels and partially blocked intake screen observed during the evaluation. This is a design, management and maintenance issue, and is avoidable. Cavitation will cause the pumps to wear out faster.

 

Figure 1:
Photos of the pump intake, showing factors likely to be contributing to pump cavitation (low water level, and a partially blocked intake screen).

What the Farmer Could Have Done Differently

PROVIDE A BETTER SPECIFICATION
Less iteration with the designers would have been necessary if the requirements of the system were better specified up front. Less of the third-party consultant's time would have been required, and the development could have started sooner.

INVEST IN UP-FRONT SITE INVESTIGATION
Earthworks cost overruns could have been mitigated by more up-front investment. Spending $5,000-10,000 on a detailed site investigation (money that would eventually be spent anyway) would have resulted in better initial cost estimates, and fewer budgetary surprises.

LOCK IN THE EXCHANGE RATE
The exchange rate should have been locked in as soon as the quotation for the irrigation equipment was accepted. In this example, a delay of just a few months cost the purchaser an additional $500/ha due to exchange rate fluctuation.

INCLUDE PERFORMANCE EVALUATION IN THE CONTRACT
Verification of system performance should have been included in the contract for the supply of the system. It should have stated the criteria that needed to be met (e.g. those in Table 1 and Table 4), as well as who was responsible for the commissioning and testing of the system. That way, if the agreed level of performance was not achieved, the purchaser would not be stuck with a system that does not fully meet their needs.

TABLE 4: ADDITIONAL ITEMS THAT SHOULD HAVE BEEN SPECIFIED AHEAD OF TIME

DESIGN OUTPUT	UNIT(S)	SPECIFICATION
Application uniformity	DU_{lq} (%)	≥ 85 %
Pump efficiency *	%	≥ 80 %
Motor efficiency *	%	≥ 90 %

* These individual efficiencies combine to equal an overall pumping efficiency of 72%. Because these items weren't specified, purchaser couldn't go back to the designer/installer when they weren't met.

INCLUDE TRAINING IN THE CONTRACT
Proper training should also be included in the contract for the supply of the system. Training in operation and maintenance of the system could have helped avoid some of the performance problems discovered during the evaluation (i.e. the partially blocked intake screen).