

van Polanen, John (2007)

Economic analysis of changing from  
border-dyke to spray irrigation

**Economic Analysis  
of  
Changing from Border-dyke Irrigation  
to  
Spray Irrigation**

**A Case Study of the van Polanen Farm**

By John van Polanen

Prepared for The Kellogg Rural Leadership Programme 2007

## **Abstract**

In recent years the van Polanen farm has intensified the grass based dairy operation which is the core activity of their farming business and it became necessary to use the limited water resource more efficiently. New technologies and practices in spray irrigation prompted an investigation into the economics of changing from border-dyke irrigation to spray irrigation. Farm Shape and watering efficiency determined the systems that were chosen. Other farmers interested in changing irrigation systems have queried the profitability of spray irrigation and this has prompted an economic analysis of the irrigation changes for the van Polanen dairy farm. Having changed from border dyke irrigation to spray irrigation has resulted in a 15% increase in milk solids, a reduction in the amount of supplements required and a substantial increase in profitability.

# **An Economic Analysis of the change from Border-Dyke Irrigation to Spray Irrigation**

## **CONTENTS**

Abstract	1
1. Introduction	3
1.1 Objectives of the Report	4
2. Why change irrigation systems?	5
3. Types of spray irrigation considered	7
4. Farm shape and watering efficiency determined the systems that were chosen	10
5. Economic Evaluation	12
5.1 Capital cost	12
5.2 Effective area	12
5.3 Labour	14
5.4 Repairs and Maintenance	15
5.5 Depreciation	15
5.6 Supplements used	16
5.7 Nutrient leaching	16
5.8 Milk Solids Production	17
6. Changes in farm profitability	22
7. Other considerations	24
8. Conclusion	26
9. References	27

## **1. Introduction**

The purpose of irrigation is to maintain the soil moisture content as close as possible to field capacity to maximize pasture yield.

Irrigation water for the van Polanen farm is sourced from the Rangitata Diversion Race (RDR) as part of a 64,000ha scheme designed for irrigation and power generation. This is an open channel scheme built in 1945 which takes water from the Rangitata River and Ashburton River to supply three farmer owned irrigation schemes. Restrictions apply to this water to maintain minimum flows in the Rangitata River and Ashburton River. At present the RDR is not able to store water and if the schemes do not require water for irrigation it is used for hydro power generation.

Traditionally most farms within the RDR scheme have applied water via border-dyke irrigation. Historically this was seen as a low cost and low labour system when compared to spray irrigation systems which were available at the time. Farming systems have intensified and there is a need to use water more efficiently. Spray irrigation is becoming increasingly popular due to improved technologies.

The consented amount of water enables Ashburton Lyndhurst Irrigation Society (ALIS) to deliver .41l/sec/ha to the van Polanen farm in the form of a 230 l/sec flow for 74 hours on a nine and a half day roster.

## **1.1 Objectives**

- To provide a case study of the advantages and disadvantages of spray irrigation versus border dyke irrigation and provide a tool to help farmers evaluate the two systems for their own properties.
- To evaluate the economic benefits for the van Polanen dairy farm as a result of changing from border-dyke irrigation to spray irrigation.

## 2. Why Change Irrigation Systems?

**Water is a limited and valuable resource essential for the profitability and sustainability of dairy farming in this area.**

The dairy farm area is 185 surveyed hectares of predominately Mayfield Silt Loam soils which have good water holding capacity. In March 2005 a previously leased adjoining area of 70ha was purchased. This land was border-dyke irrigated and in need of upgrading to improve watering efficiency.

The following options were considered:

- Renew the border-dyke system to wide borders.



**Figure 2.1:** Border-dyke irrigation.

This system relies on the gradient of the land (gravity) to run water down open channels to flood irrigate strips of land known as borders by the use of dams and applies 85mm of water every 24 days. As this requires a complete renewal of the pasture and the shifting of topsoil it would take up to ten years to complete the re-bordering.

- Replace some or all of the borders with spray irrigation.

### 3. Types of Spray Irrigation Considered

#### Rotorainer

This would apply 50 mm of water every 14 days .This would require daily shifts to irrigate 100m wide strips up to 600m long and requires medium water pressure to operate.



**Figure 3.1:** Rotorainer Irrigator

## **Gun Irrigator**

This has the same application rate as a Rotorainer. It is easier to shift but the watering pattern can be greatly affected by wind and requires a higher water pressure to operate than the Rotorainer. This system was not chosen as it was considered to be less efficient.



**Figure 3.2:** Gun Irrigator

## Centre Pivot

This can apply between 5mm and 80mm of water. This machine is self propelled around a pivot point therefore no labour is required for daily moving. A pivot operates under low water pressure and is recognised as having a high watering efficiency. Due to the circular pattern of irrigation corners are not irrigated and therefore require the installation of small sprinklers.



**Figure 3.3:** Centre Pivot

**It should be noted that due to the water consent all the systems only have .41l/sec which equates to an application rate of 3.5mm/day.**

#### 4. Farm Shape and watering efficiency determined the systems that were chosen.

The dairy farm has an 80ha support block which is irrigated using a Turbo Rain irrigator. Observations on this area indicated that spray irrigation had significant advantages over border dyke irrigation in terms of pasture growth. Calculations and advice from advisors and other farmers indicated that the extra grass grown under spray irrigation would increase farm profitability and the decision was made to spray 140ha of the dairy farm covering paddocks 8 through to 31 (Figure 4.1).

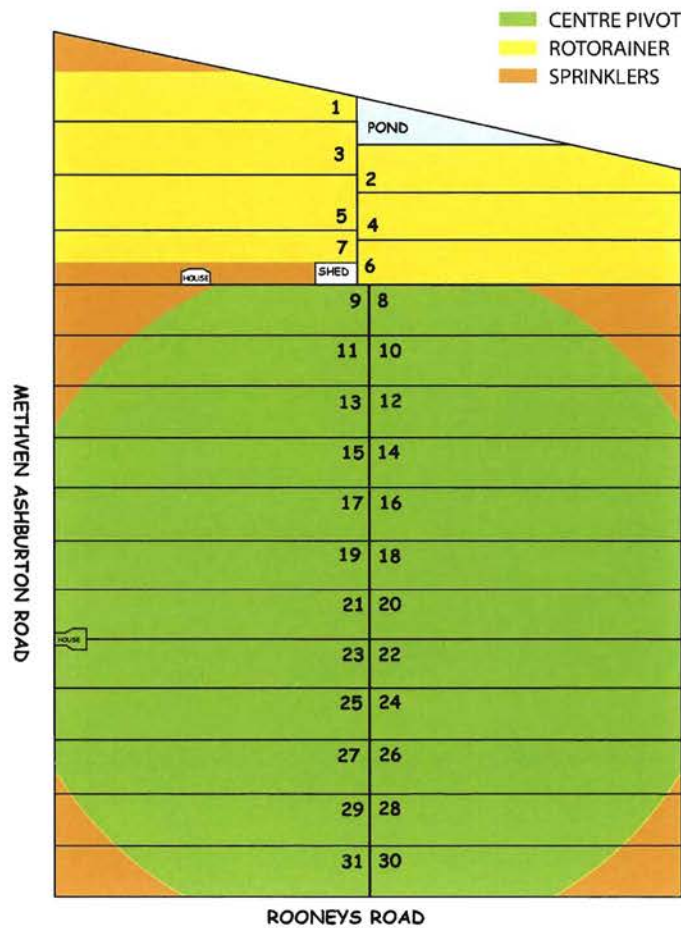


Figure 4.1: Farm map showing area and type of irrigation

The shape of this area suited a centre pivot or Rotorainer. A centre pivot was chosen due to its low labour requirements and higher watering efficiency. A 35,000 cubic meter pond was built to hold the rostered flood flow until it could be used for spray irrigation. The remaining 45ha was to remain in border-dyke irrigation. However, after less than one year of center pivot irrigation, the recorded difference in grass growth (1500 kg/ha/year) between the two systems left no doubt that the 45ha under the border-dyke system would be best irrigated with a Rotorainer.

## 5. Economic Evaluation

The economic evaluation of the change in systems was able to be definitively calculated in the following areas:

### 5.1 Capital Cost

The cost of a complete spray system and pond	\$407,000.00
Less 157ha that required re-bordering @ \$1,500/ha.	<u>\$235,500.00</u>
<b>Extra capital cost for spray irrigation</b>	<b><u>\$171,500.00</u></b>
<b>At 8% cost of capital this is \$13,720.00/annum</b>	

### 5.2 Effective Area

An increase in effective area was acquired through:

#### 5.2.1 Dry Land

This was an area of 3.5 ha that was not able to be watered as it was either the areas between buildings or was too high for water to flow etc.

#### 5.2.2 Laneways

Farm layout was previously designed around irrigation channels and borders. The change to spray irrigation gave the opportunity to simplify paddock layout and remove 2,500

meters of laneways which were 6 meters wide. This is 1.5ha which now equates to the size of the irrigation water holding pond.

### **5.2.3 Borders**

There were 108,700 meters of borders each having an area on the top of the border which dried out and grew poorer grasses and weeds. On average these dry areas are 400mm wide and would cover 4.35 ha in total.



**Figure 5.1:** Top of a border

### **5.2.3 Irrigation Channels**

There were 7,708 meters which were an average of 5.7 meters wide and covered 4.4 ha in total. These also dried out and grew poorer grasses and weeds.

The area in borders, irrigation channels and dry land (12.25ha) was still grazed but grew 60% less grass than the irrigated area. Under spray irrigation this area is now fully irrigated which means that in effect we have gained 60% of 12.25ha or 7.35ha. This is an increase of 4% in effective area.

## **5.3 Labour**

The roster for border-dyke irrigation made water available 3 days out of 9 and required 3 hours of labour to manage this rostered period. This equated to 1 hour/day.

Water for the spray irrigation is delivered on the same roster system but is able to be held in the pond (Figure 4.1) and used as required. The Rotorainer requires seven shifts over a 14 day period and takes approximately one hour to shift and when added to checking the center pivot and shifting small corner sprinklers the total time to manage a spray system is one hour per day.

No labour savings have been made but the spray irrigation offers more flexibility in the timing of labour. Irrigation work can now be avoided on weekends and during the night.

## 5.4 Repairs and Maintenance

### 5.4.1 Border-dyke System

Repairs and maintenance in a border-dyke irrigation system includes channel cleaning and repairs to clocks, dams, sills and culverts with an average annual cost of \$3,000. Long term maintenance required 5% of the borders and channels be renewed annually.

5% x 171 ha = 8.5 ha @ \$1500	\$12,750
System R & M	<u>\$ 3,000</u>
Total	<u>\$15,750</u>

### 5.4.2 Spray Irrigation

Annual check and lubricants	\$1,200
Long term R & M (est.)	<u>\$5,000</u>
Total	<u>\$6,200</u>

## 5.5 Depreciation

Border-dyke upgrading is accounted for on an annual basis in Repairs and Maintenance so no depreciation has been calculated.

To calculate depreciation on the \$407,000.00 spray irrigation system it is accepted that a 4% average depreciation rate over all components would be an acceptable figure.

$$\$407,000 \times 4\% = \$16,280.00$$

## 5.6 Supplements Used

In an average season during January and February the long irrigation interval determined by the border-dyke system resulted in a rapid decline in grass growth. In most summers it was necessary to feed 70,000kg DM in the form of silage to compensate for this decline.

Supplementary feeding with silage has not been required during the January/February dry period since changing to spray irrigation. The increased stocking rate has resulted in an increase of 38,000 kg DM being fed on the shoulders of the production season.

The net result has been a saving of 32,000kg DM @ 27c/kgDM = \$8,640.00

## 5.7 Nutrient Leaching

A trial at Lincoln University (Moore, 2002) showed that less nitrogen is being leached under spray irrigation when compared with flood irrigation. In this trial twice the volume of water was applied by flood irrigation which resulted in twice the amount of nitrate leached. From this trial it can be calculated that on a farm stocked at 3.5 cows/ha the difference in N leached was 80 kg/ha for flood irrigation and 40 kg/ha for spray irrigation.

Under spray irrigation the van Polanen farm uses less water in an irrigation season but is likely to use the same amount of water in December, January and February as was used by border-dyke irrigation.

To date the limited information gathered indicates that the farm will use 200mm less irrigation water for the season. Because of this we know that there will be less N leached when using spray irrigation. On farm observations indicate that we are obtaining longer N

responses than under border-dyke irrigation. We presume that this is due to the lower volume of irrigation water being used which reduces the amount of N being washed away from the plant root zone. The economic benefits from this are being expressed through the extra grass being grown and reflected in the increase in milk solids.

The OVERSEER nutrient budget also recognises changes in nutrient losses between border-dyke and spray irrigation. For the van Polanen farm the nutrient budget calculated the differences in Table 5.1.

**Table 5.1:** Nutrients saved using spray irrigation as calculated using the OVERSEER nutrient budget.

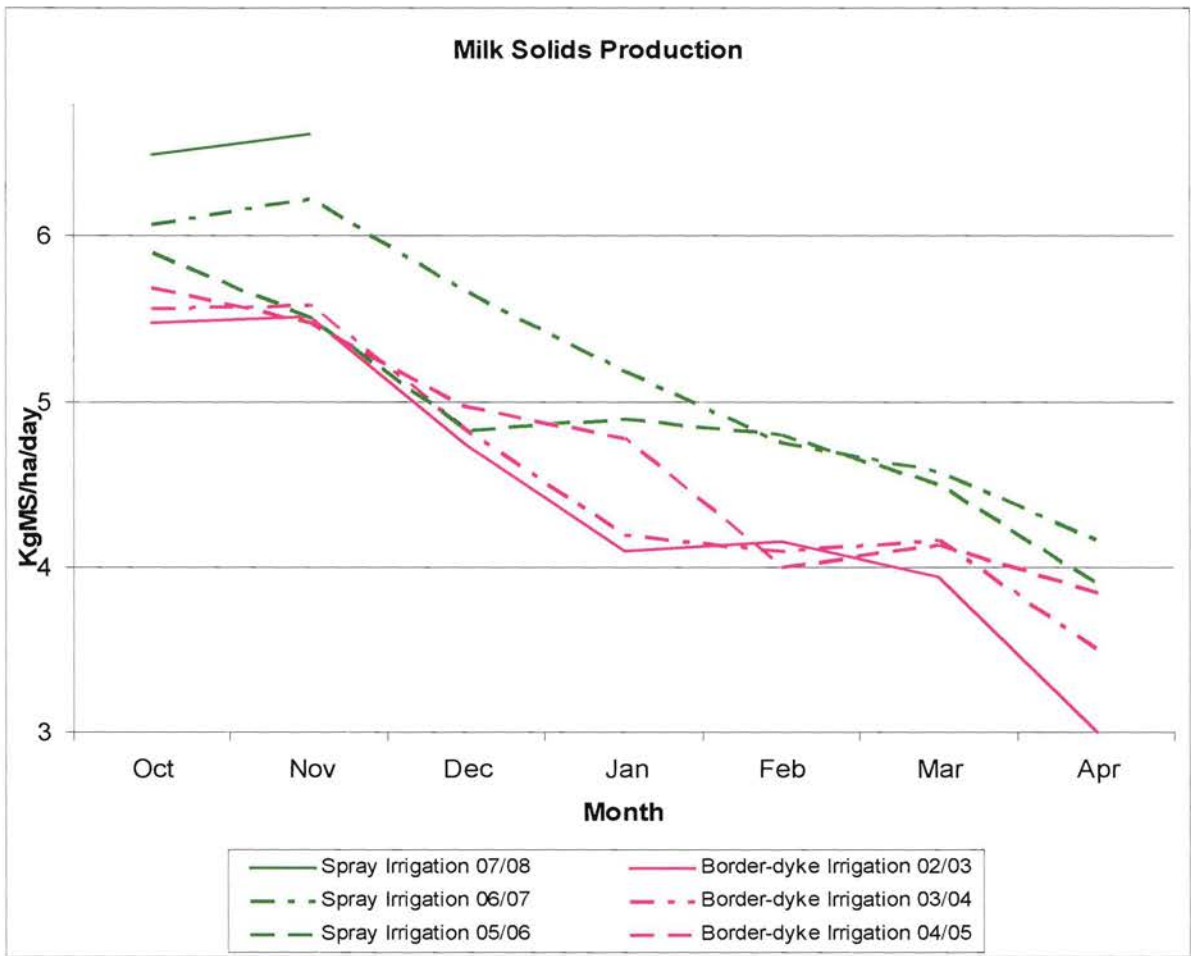
<b>Nutrient</b>	<b>Kg/ha Saved</b>	<b>% Reduction in losses</b>
Nitrogen	7	20
Calcium	5	10
Magnesium	1	10

## **5.8 Milk Solids Production**

The period from October to April, as used in Figure 5.2, is most likely to reliably show the effects irrigation changes have made to production. The other periods are likely to be affected by temperature, calving pattern and other management factors.

Milk solids production in January 2004 was well above average due to higher than average rain fall in late December and early January.

Production for the 05/06 season was following a similar pattern to previous seasons until the commissioning of the centre pivot in mid December.



**Figure 5.1:** Milk Solid Production Graph

Significant production increases occurred in the 06/07 season despite the re-grassing of 23% of the farm compared to the 6% re-grassed in previous seasons.

Pasture growth records show that the re-grassed area grew slightly less grass for the season compared to the old pastures. This was due to the 56 days of grazing that is lost during pasture renewal.

Total milk solids increased by 4,100 kg in the 05/06 season and a further 16,200 kg in 06/07. Production for the current season is estimated to increase by a further 16,500 kg giving 15% increase in production over three seasons.

**5.8.1** The increase in production has occurred through:

**1. A 4% increase in effective area.**

*(As discussed in 5.2)*

**2. Pasture quality.**

Since the change to spray irrigation the cows have grazed the pastures more evenly and the quality has improved particularly in the December to February period. It is difficult to arrive at any definite conclusions for the change in pasture quality as most of the pastures have not been renewed and the old borders remain in the paddock. Possible reasons could be:

- Flood irrigation causing movement of nutrients to the outer edges of the borders and making the grass less palatable.
- Plants becoming moisture stressed due to the long irrigation interval on the border-dyke system.

With growth at 50 kg/ha/day during the mid December to February period a change in ME from 11 MJ to 11.5 MJ would result in an extra 25 MJ ME/ha/day which could be converted to .4kg MS/ha/day. Over this sixty day period on 178 effective hectares this equates to 4,272 kg MS on 178 effective hectares.

### **3. Water Efficiency**

The greatest increases in milk production have occurred between mid- December to mid-February. Silage is no longer required in this period and the increases in production are greater than the effects of an increase in effective hectares and pasture quality.

Pasture growth measurements taken in the border-dyke and pivot irrigation areas in the first year showed that half of the extra 1,500 kg DM was grown in mid December through to mid-February. These figures have only been able to be recorded for one year but strongly indicate that the application of 21 mm water every 6 days, as under centre pivot irrigation, resulted in increased grass growth when compared to applying 80 mm every 23 days.

## 5.8.2 Calculations to account for the Milk Production Increases

	<i>Kg DM</i>
171 ha growing an extra 1,500kg DM/ha	256,500
7.35 ha increase in effective hectares @ 16,500 kg DM/ha	121,275
32,000 less supplement used	<u>(32,000)</u>
<b>Net gain in kg DM available for production</b>	<b><u>345,775</u></b>

	<i>Kg MS</i>
It takes 11 kg DM to produce 1 kg MS	31,414
Effect of ME change as in 5.8.1	<u>4,272</u>
<b>Calculated increase in production</b>	<b><u>35,706</u></b>

**The calculated increase in production of 35,706 kg MS is very similar to the recorded increase in production of 36,800 kg MS.**

## 6. Changes in Farm Profitability

	\$	\$	\$
<b><u>Increase in Income</u></b>			
36,000 kg/MS @ \$5.20		187,200	
Stock Sales		<u>9,360</u>	
<b>Total increase in income</b>			<b>196,560</b>
 <b><u>Increase in Expenses</u></b>			
Animal Health     75 cows @ \$51.00		3,825	
Herd Expenses     75 cows @ \$30.00		2,250	
Grazing             75 cows @ 8 weeks x \$18	10,800		
15 heifers x 52 weeks @ \$7	5,460		
15 calves x26 weeks @ \$3.50	<u>1,365</u>	17,625	
Electricity (Irrigation)		20,000	
Depreciation on irrigators and pumps <sup>1</sup>		16,280	
Insurance		800	
Dairy Shed           75 cows x \$26		1,950	
Capital costs @ 8%   Irrigator/pumps	13,720		
75 cows @ \$1,600	9,600		
15 heifers @ \$700	840		
36,000 Fonterra Shares @ \$6.40	<u>18,432</u>	42,592	
<b>Total increase in expenses</b>			<b>(103,472)</b>

---

<sup>1</sup> Refer to Section 5.5 *Depreciation*

		\$	\$
<i>Total Increase in Income</i> <sup>2</sup>			<i>196,560</i>
<i>Total increase in Expenses</i> <sup>3</sup>			<i>(103,472)</i>
<b><u>Decrease in Expenses</u></b>			
Supplements <sup>4</sup>	32,000 kg x .27 c	8,640	
Repairs & Maintenance <sup>5</sup>		<u>9,550</u>	
			<b><u>18,190</u></b>
<b>Net Increase in Farm Profitability</b>			<b><u>111,278</u></b>

---

<sup>2</sup> Figures carried over from previous page  
<sup>3</sup> Figures carried over from previous page.  
<sup>4</sup> Refer to Section 5.6 *Supplements Used*  
<sup>5</sup> Refer to Section 5.4 *Repairs and Maintenance*

## 7. Other Considerations

The following are considerations which have not been recognised in the economic analyses. Many of these have environmental impacts and have the potential to affect the economic returns for the farm.

- 1 The Rotorainer has allowed tree lines to remain but this has not been the case for the center pivot area. Approximately 2,100 meters of internal tree lines were removed from the centre pivot area. To date 1,800 meters of shelter has been planted around the perimeter of the farm and a further 600 meters of natives have been planted under the pivot to provide some shelter to stock and as a food source for birds.
- 2 Less nitrate and other nutrients being leached which in the long term will have a beneficial effect on ground water.
- 3 Under border-dyke irrigation the tops of borders and channels dried out and opened up the pasture species allowing weeds to establish. Well irrigated and dense pastures will result in less weeds and it is likely that less pasture renewal will be required.
- 4 Flat paddocks will be easier and less expensive to renew pasture and mow paddocks and will be easier on machinery, tractors and motorbikes.
- 5 Cows previously slept and rested beside borders and this caused nutrient transfer through dung and urine patches. The cows now rest at random throughout the paddock.
- 6 The centre pivot offers the opportunity to spread effluent over a large area with minimal labour.

- 7 Electricity is required to pump water but this energy cost may be offset by the energy saved due to less supplements being used.

## **8. Conclusion**

This case study clearly demonstrates the change from border-dyke irrigation to spray irrigation has resulted in a substantial economic return for the van Polanen dairy farm. The change has allowed the business to grow by 15% without the need to sell or purchase more land.

Farmers must evaluate their own specific business to determine the viability of a change in irrigation type. Irrigation method will be largely determined by farm shape, capital available and the personal drive for efficiency and intensification. The profitability will be determined by the value of the product grown.

## 9. References

Moore, S 2002, *Influence of irrigation method on N leaching and water use efficiency in grazed pasture: a comparison of spray vs. flood irrigation*, Lincoln University, New Zealand.

McFarlane, A Farm Consultant. Personal interview on 10 September, 2007.

Cameron, K Professor Lincoln University. Personal interview on 18 September, 2007

White, G Farm Consultant. Personal interview on 8 November, 2007.

Mayne, R Irrigation consultant. Personal interview on 15 November, 2007.