CASE STUDY 2

OPTIONS FOR IMRPOVING BORDER-CHECK IRRIGATION PERFORMANCE ON LIGHT SOIL

Background

The landowner operates a 100 hectare dairy farm in the Nathalia district. Thirty-one hectares are irrigated with centre pivot. Sixty hectares of the farm, on heavy soil types, is well developed to laser-graded bays served by a good drainage reuse system. However, a remaining 9 hectare section on light soil types has a layout that is too flat for the installed border-check system and irrigation is inefficient and time-consuming.

Using the 5-Step decision-making processes, the landowner made the following assessment of his property and made an informed decision on the adoption of a system that best fits his property.

STEP 1: What do I want to achieve?

This step helped the landowner to identify what he wanted to achieve on his farm. The landowner wanted to *evaluate options for reducing deep drainage through re-designing the current irrigation system*

STEP 2: What are my farm's features and constraints?

The 9 hectare section (Figure 1 below) was considered too small and the wrong shape for conversion to centre pivot irrigation. The landowner decided to up-grade the existing border-check layout to modern standards and include an automated system.

The supply channel has a limited capacity of 5 to 6 ML/day and because of the light soil texture there are substantial losses of water through deep drainage. Groundwater pumping is considered an option to pick up these drainage losses for re-use. Overall, they needed to do an in-depth evaluation of their current system and consider all potential options for improvement. They moved straight to Step 2.3.7.1 of the decision-support Guidelines.

STEP 2.3.7.1: How much water can I potentially save?

The irrigation system is an important component of the farm business. A review of the system performance was able to identify areas for improvement, including reducing deep drainage, waterlogging and better scheduling of irrigation. Pasture water requirement is largely determined by climatic demand and is a critical factor in the evaluation of potential water savings. Potential water savings being the difference between *currently applied irrigation plus rainfall* and *pasture irrigation requirement*.

Table 1 indicates the potential water savings that were determined for this site using applied water data from the wheel, rainfall records and irrigation requirement information from Step 2.3.1 in the Guidelines.

Table 1: **Water balance for the site**

Year	Irrigation Applied + Rain ML/ha	Irrigation Requirement ML/ha	Potential Water Saving ML/ha
2005/06	13.1	10.3	2.8

As shown, 2.8 ML/ha have been used in excess to pasture water requirement. The landowner needed to determine the possibility of reducing these losses through improved irrigation design. The landowner moved straight to Step 4.1.2.2 in the decision support Guidelines.

STEP 4.1.2.2: What slope, length and width, and discharge should my bays have?

Based on the information in Table 1, irrigation efficiency over the 2005/06 season was 79%; the pasture only used 79% of the applied irrigation plus rain. However, well-designed and managed border-check irrigation systems can achieve efficiencies of more than 90%.

Deep drainage losses of 0.5 to 1.0 ML/ha/year need to be allowed in addition to the irrigation requirement of perennial pasture to allow for leaching of salts below the root-zone. Loss of greater than 1 ML/ha/year is considered excessive.

In the current system, the owners tried to drain excess water off the bays as quickly as possible after irrigation to minimise the period of water logging and excessive deep drainage. They used spinner cuts to enhance surface drainage and the farm supply channel has been sealed to reduce seepage. They believe this is not enough for the light soil on the site and their conclusion is supported by the water balance information in Table 1 (above). They needed to consider their options carefully before carrying out expensive earth movement works.

Staff from the Department of Primary Industries have worked with the owner to investigate options for reducing the excess deep drainage. The Analytical Irrigation Model (AIM) (Austin and Prendergast, 1997; Robertson et al., 2001) was used to evaluate the impact of different management and design options on deep drainage losses. These options included changing flow rate, halving the length of the bays and/or changing bay widths.

There is only limited scope for reducing these losses by either increasing flow rates and/or decreasing the bay widths. The AIM model suggested that a significant reduction could be obtained by halving the bay length, without compromising irrigation uniformity.

STEP 5: What options best meet my goals?

Following the irrigation system selection and design Guidelines and taking on board the AIM model and suggestion of halving their bay lengths, the landowner has now made an appointment with their irrigation designer for further discussion.

Halving the bay length will increase the number of bays and increase the labour requirement to operate their irrigation system. By halving their bay length, the farmer plans to consider automation of the irrigation system to achieve labour savings and to reduce deep drainage losses.

A groundwater pump near the block will intercept any unavoidable losses to the watertable due to the light soil type on the site, and the ground water pump will be used for irrigation on the site.

Figure 1: Case Study 2 site

IRRIGATION MODELLING FOR CASE STUDY 2

Background and Objectives of the Study

Excess deep drainage results in rising water tables and increases the salinity risk in irrigated agriculture. The efficiency of irrigation systems can be improved by reducing deep drainage.

Both lysimeter and field-scale studies have shown that deep drainage under surface irrigation can be calculated as the product of the final infiltration rate of the soil and the period of ponding during irrigation (Bethune et al., in preparation). The Analytical Irrigation Model (AIM) (Austin and Prendergast, 1997; Robertson et al., 2001) can be used to estimate the final infiltration rate and the period of ponding under a wide range of surface irrigation scenarios. The AIM can be used to assess whether deep drainage can be reduced for any given irrigation system.

In this study the AIM was used to assess whether changing the existing design can reduce deep drainage and/or the management for a section of a border-check irrigated dairy farm near Nathalia in northern Victoria.

Material and Methods

Using the AIM, deep drainage losses were assessed for different design and management options as follows:

- Changing the irrigation flow rate;
- Halving the length of the irrigated bays; and
- Changing the width of the irrigated bays.

The duration of irrigation was adjusted to simulate a *no runoff* scenario.

Deep drainage was calculated as the product of the *final infiltration rate* as used in AIM and the *ponding time*. The ponding time was derived from advance and recession times predicted by AIM.

Results

Changing the bay width/flow rate

The current surface irrigation layout has bay widths of 50 metres and an average flow rate on the bays of 8 ML/day, including 6 ML/day from the channel and 2 ML/day from a groundwater pump.

For this system, AIM predicted 277 mm deep drainage over the irrigation season. The *measured* deep drainage over the 2005/06 season was 279 mm (Qassim et al., in preparation), which indicates that the model provides a reasonable representation of the current performance of the irrigation system.

By changing the bay width and/or the flow rate, the maximum reduction in deep drainage calculated by AIM was 24 mm (Table 2, below), suggesting only limited potential to reduce deep drainage by changing the bay width and/or the flow rate.

Doubling the flow rate has the same effect on deep drainage as halving the bay width. Increasing the flow rate and decreasing the bay width typically decreased the irrigation uniformity (Table 3). Halving the bay widths and/or increasing the flow rate up to 12 ML/day yielded irrigation uniformities of less than 0.9, which may cause under-irrigation of the top section of the bay. The uniformity can be improved by allowing runoff, which will increase deep drainage.

Table 2: Estimated deep drainage (mm) per irrigation season (19 irrigation events) for the current 350 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	264	292	332
8	257	**277**	303
10	254	268	287
12	253	264	278

Fifty metre bay widths and 8 ML/day flow rates represent the current system. Actual measured deep drainage was 279 mm. Final infiltration rate was 2.7 mm/h.

Table 3: Irrigation uniformity for the current 350 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	0.89	0.94	0.95
8	0.87	**0.92**	0.94
10	0.85	0.90	0.93
12	0.88	0.89	0.92

Table 4: Estimated duration of irrigation (minutes) for the current 350 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	97	198	310
8	72	**147**	226
10	58	116	178
12	48	97	147

Halving the bay length

Halving the bay length can reduce deep drainage by nearly 100 mm per irrigation season compared to the current situation (Table 5 vs Table 2). The impact of increasing the flow rate or reducing the bay length on deep drainage was minimal for both 175 metre and 350 metre length scenarios. The uniformity of irrigation was little effected by changes in the bay length. All scenarios had uniformities greater or equal to 0.9 (Table 6).

Table 5: Estimated deep drainage (mm) per irrigation season (19 irrigation events) for 175 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	176	188	202
8	174	**181**	192
10	173	179	185
12	171	176	181

Table 6: Irrigation uniformity for 175 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	0.92	0.92	0.94
8	0.91	**0.90**	0.92
10	0.90	0.93	0.91
12	0.90	0.92	0.90

Table 7: Estimated duration of irrigation (minutes) for 175 metre bay length with different irrigation flow rates and bay widths

Flow rate [ML/day]	Bay width [metres]		
	25	**50**	**75**
6	44	88	134
8	33	**66**	100
10	26	53	79
12	22	44	66

Summary and Conclusions

Different management and design options for improving a surface irrigation system near Nathalia were assessed. The impact of these options on deep drainage was evaluated using AIM.

There is only limited scope for reducing deep drainage by increasing flow rates and/or decreasing the bay width. Significant deep drainage reduction could be obtained by halving the bay length. The irrigation uniformity was not compromised by this option.

References

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