# Irrigation Design

## Prepared for
## Lismore Farm and Hawkdun Irrigation Co

**Report No 4606/2**

**October 2003**

LINCOLN ENVIRONMENTAL
A division of Lincoln Ventures Ltd

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# 1 INTRODUCTION

The Maniototo Plains have a long history of irrigation that stretches back to 1929 when the Hawkdun Irrigation Scheme was opened. The Scheme obtains water from run-of-river takes from numerous small rivers and creeks that drain the southern and western flanks of the Hawkdun Ranges. Water supply is predominantly from mountain runoff, with some storage provided by the 2.4 million $m^3$ West Eweburn Dam. The Scheme uses the old Mount Ida mining race, which stretches for over 60 km from a weir on Johnston Creek (a tributary of the Manuherikia River) and runs around the base of the Hawkdun Ranges to Naseby. The Scheme was developed to provide a variable supply to approximately 3,580 ha from Gimmerburn to Naseby. The majority of the area serviced is irrigated using contour or wild flooding techniques, although a number of small spray irrigation operations have been established recently.

As an addition to a recent project for the Ida Valley Irrigation Focus Group, the Hawkdun Irrigation Co contracted Lincoln Environmental to undertake irrigation monitoring on one farm (Lismore) on the Hawkdun Irrigation Scheme and to develop a plan for future irrigation development on the property. This report describes the results of the monitoring, and outlines the three irrigation development options suggested for Lismore. While this report is primarily focused on Lismore, it also contains some general comments regarding both the Hawkdun Irrigation Scheme and the issues associated with irrigating in the vicinity of Ranfurly. As such, it was anticipated that the recommendations made for Lismore would be transferable to other similar farms on the Hawkdun Irrigation Scheme.

Given the similarities between the Hawkdun and Ida Valley irrigation schemes, it is considered appropriate to provide a brief summary of the monitoring undertaken in Ida Valley, as it provides the context in which the Hawkdun study was undertaken. Similarly, the reader is referred to the main Ida Valley report – Report No 4590/1 (LE, 2003).

## 1.1 The Ida Valley Project

The Ida Valley project was aimed at identifying practical and affordable ways in which Ida Valley farmers could produce more with the water that is available to them and how they can use the water more efficiently. As part of the project, the following investigations were undertaken:

- Soil moisture monitoring;
- Monitoring of current irrigation efficiency; and
- The development of recommendations on how irrigation efficiency could be improved.

The object of the soil moisture monitoring was to provide local farmers with sufficient information to allow them to schedule irrigation to maximise irrigation efficiency. This was achieved by continuously monitoring soil moisture at various sites within the valley, processing the data in real time, and presenting the findings in a manner that was readily accessible to local farmers.

Investigation of current irrigation efficiency was aimed at benchmarking existing irrigations practices, calculating the efficiency of those practices and, specifically, to determine if there were significant differences between different methods of irrigation. To this end, five representative farms covering four methods of irrigation (wild flooding, border-dykes, K Line and gun) were selected for detailed investigations.

The development of recommendations on how irrigation efficiency could be improved focused on using the five representative farms as case studies and developing recommendations for each of the farms. In doing this it was anticipated that the recommendations made on the representative farms would be transferable to other similar farms in the area. For each representative farm three options for potential irrigation development were prepared.

As part of the Ida Valley project, six reports were produced. The first report covers the soil moisture and irrigation efficiency monitoring, along with general recommendations for improving irrigation efficiency in the Ida Valley (Report No 4590/1). The remaining five reports cover each of the representative farms, with each report describing in detail the three irrigation development options suggested for each farm.

## 1.2 This Report

This report initially provides some background on the water requirements and actual evapotranspiration (AET) rates experienced in the Ranfurly area. It then focuses on Lismore by covering the following objectives:

- To briefly document the current farm and irrigation management methods.
- To quantify the water available for irrigation.
- To determine how much area can be irrigated with the volume of water available.
- To determine which areas should be targeted for irrigation by considering soil type, topography, the position of the water source, and other variables such as power supply, etc.
- To recommend three methods for irrigating the selected area and to develop conceptual plans, including bills of materials for each of the three methods. The selection of the three methods has involved close liaison with Ally and Helen Dowle (owners of Lismore) to ensure that the three future plans match their expectations.

The above objectives form the structure of the following sections.

# 2 WATER REQUIREMENTS

The climate of the Ranfurly area and the greater Central Otago region is characterised by cold dry winters and hot but slightly wetter summers. A climate station was operated at Ranfurly from 1975 to 1989, and the existing Ranfurly station was established in 2000. Rainfall records from both stations indicated that average monthly rainfall peaks at approximately 50 mm in December and January, and falls to a low of 22 mm in July and September. Average annual rainfall was approximately 400 mm, although yearly totals ranged from a maximum of 550 mm in 1983 to a low of 217 mm recorded in 1988.

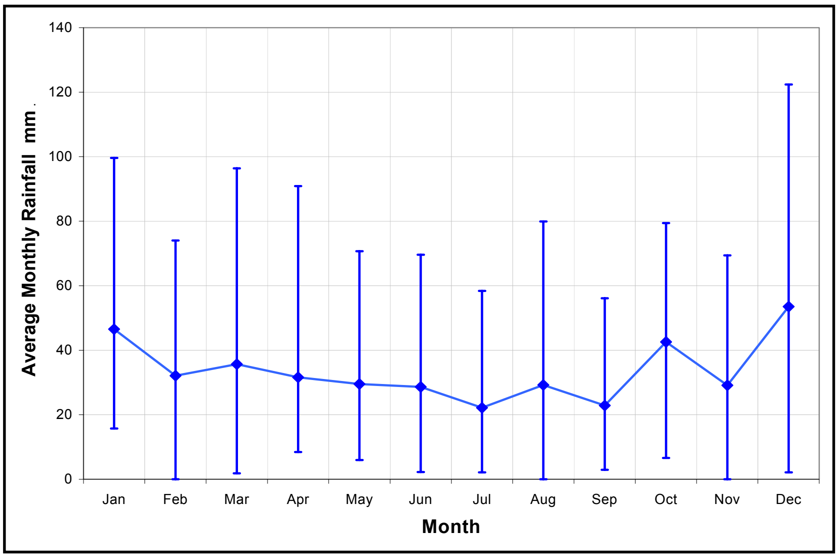



*Figure 1: Monthly rainfall recorded at Ranfurly from March 1975 to July 1989 and from November 2000 to May 2003*

Potential evapotranspiration (PET) recorded at the same climate stations indicated that average daily Penman PET peaks at slightly over 4.1 mm/d in December and January, and falls to a low of 0.4 mm/d in July and August. Many extreme events have been recorded, with daily levels of greater than 6 mm not uncommon.

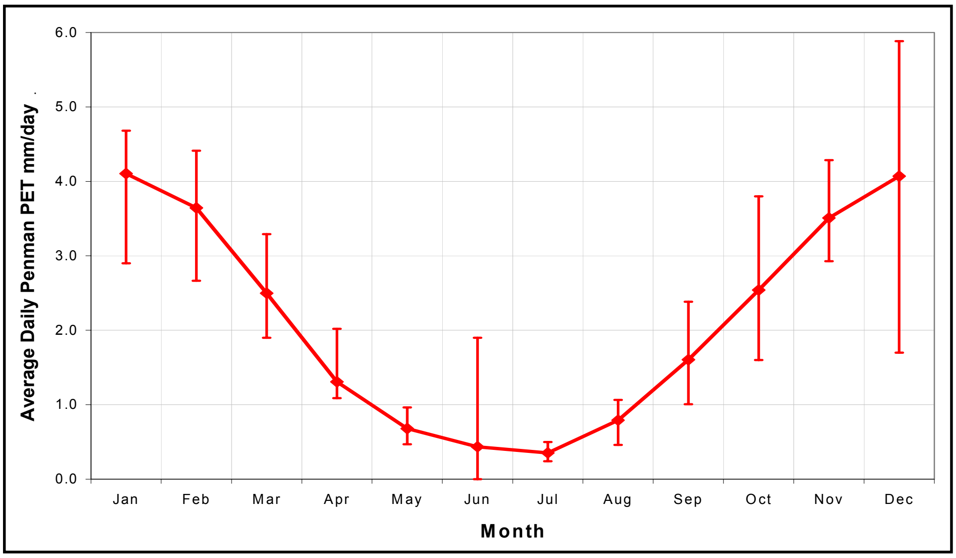



*Figure 2: Average daily Penman PET recorded at Ranfurly from March 1975 to July 1989 and from November 2000 to May 2003*

The relatively low rainfall and high PET rates over summer result in large soil moisture deficits, and extensive irrigation is required to maximise production.

## 2.1 Theoretical System Capacity

Using a soil water model with climate data from the Ranfurly climate station (1975-1989, 2000-present), we were able to predict irrigation demand for Lismore and to determine the optimum spray irrigation regime for irrigating pasture. In order to use the model, an irrigation regime had to be determined, namely the soil type and water-holding capacity, length of the irrigation season, the trigger level for irrigation, the depth applied, an irrigation rotation, the coefficient of uniformity of the irrigation method and the potential maximum rooting depth. The following numbers were used:

*Table 1: Irrigation regime for irrigating pasture near Ranfurly*

| | |
|---|---|
| **Crop** | Pasture |
| **Soil type and plant available water (PAW)** | Becks, 90 mm |
| **Irrigation season** | 1 October to 30 April |
| **Soil moisture trigger for irrigation** | 50% of PAW |
| **Application depth** | 45 mm |
| **Min Return period** | 7 days |
| **Coefficient of uniformity** | Spray 80% |
| **Potential rooting depth** | 600 mm |

The model predicted that, for optimum irrigation, a system capacity of 0.4 ℓ/s/ha was required, with an optimum return period of 13 days. Under such a regime, the PAW drops below 50% only 7.5% of the time and below 25% approximately 1% of the time. Such irrigation would result in optimum grass growth, as the pasture would never be under significant water stress. However, such a regime would also result in a significant amount of drainage, namely water that drains through the soil profile and is lost to the pasture. Converting the irrigation regime to an annual water balance indicated that, for an average year, 490 mm of irrigation water would be required (Table 2). It is noted that a system capacity of 0.4 ℓ/s/ha is significantly lower than the 0.6 ℓ/sha result obtained from both Lauder (in Central Otago) and Winchmore Research Centre (near Ashburton).

*Table 2: Average annual soil water balance under optimum irrigation near Ranfurly based on local climate date from 1975-89 and 2000-03*

| **Parameter** | **Dryland** | **Optimum irrigation** |
|---|---|---|
| Rainfall | 382 | 382 |
| AET | 380 | 773 |
| Irrigation | 0 | 490 |
| Drainage | 3 | 98 |
| Net irrigation use | 0 | 392 |

Based on the modelling, we would suggest that irrigation schemes in the Ranfurly area be designed to apply close to 500 mm/y with a system capacity of between 0.35 and 0.40 ℓ/s/ha. Applying less than 500 mm/y is likely to result in a significant decrease in production, particularly during any year which is drier than average. System capacities of less than about 0.3 ℓ/s/ha are likely to result in the system not being able to cope during the periods of peak irrigation demand at the height of the season in January and February. Similarly, low system capacities significantly restrict an irrigator's ability to catch up after periods of high irrigation demand. The reader is referred to the Ida Valley report (Report No 4590/1), which contains a more detailed explanation of system capacity and potential production.

## 2.2 Current Practice

Current irrigation practice over most of the Hawkdun Irrigation Scheme is to spread the water thinly over as wide an area as possible, particularly at the start of the season when the full allocation is generally available. During the height of the season, the reduced allocation (due to reduced river flows) and high rates of evapotranspiration force irrigators to concentrate on smaller areas. As such, the system capacity of the existing irrigation will be well below 0.4 ℓ/s/ha. On Lismore, under wild flooding, the Dowles were irrigating approximately 80 ha. Based on the average flow received over the 2002-30 season, the 80 ha was irrigated at a system capacity of only 0.1 ℓ/s/ha. Discussions with Ally Dowle indicated that of the 80 ha, only 20-30 ha was considered well irrigated. Assuming all the water was supplied to this smaller area, the system capacity was 0.45 ℓ/s/ha for 20 ha and 0.3 ℓ/s/ha for 30 ha. Similarly, it is understood that Barry Smith (a local farmer) is currently irrigating 175 ha with K

Lines, using 1½ head, which corresponds to a system capacity of 0.24 ℓ/s/ha. The low system capacity currently being used on the Hawkdun Irrigation Scheme corresponds well with the results from Ida Valley, where investigations indicated system capacities of 0.38 ℓ/s/ha for K Lines and 0.3 ℓ/s/ha for large guns. It is considered that such low system capacities are likely to significantly reduce production on the irrigated area.

The nature of the Hawkdun Irrigation Scheme being run-of-river, and subject to frequent periods of low flow, results in the irrigators having a very low security of water supply and experiencing regular fluctuations in water supply. This in turn makes it very difficult to design and operate an effective irrigation scheme, as irrigators are required to have sufficient capacity (i.e. a sufficient number of K Lines, a large enough centre-pivot, or a large enough area of wild flooding or borders) to allow them to fully utilise their full quota. However, for large portions of the season, the irrigators might not receive their full quota, and would be required to irrigate only select areas. This has the problem of irrigators having to invest in irrigation infrastructure that they will not be able to use all the time.

# 3 CURRENT FARM AND IRRIGATION MANGEMENT

Lismore is a 480 ha property on the outskirts of Ranfurly, and is farmed by Ally and Helen Dowle in conjunction with a neighbouring 500 ha property that they lease. This report is focused on the Lismore property, although it is noted that the lease property also receives water from the Hawkdun Irrigation Scheme and has an existing small storage reservoir. The topography of Lismore is predominantly flat, with a number of small gullies and a terrace down to the Eweburn Creek. Four soil types are present on the property: bony Eweburn's on the lower terrace adjacent to the river, Struan sandy loams at the top of the property, Naseby sandy loams through the middle section where State Highway 85 (SH 85) cuts through the property, and Becks sandy loam over the lower part of the property near the homestead. A clay pan exists at a depth of approximately 600 mm over much of the property, resulting in perched water tables. As at June 2003, 347 ha of Lismore was in permanent pasture of varying ages, 9 ha was in feed crops, 80 ha was in lucerne, 24 ha was fallow with the balance of the property (approximately 20 ha) covered in woodlots, shelter belts, the terrace face and unimproved riverbed adjacent to the Eweburn Creek. The lucerne is mainly located on the bony Eweburn soils where there is no soil pan and where the deep rooting lucerne can tap the high groundwater associated with the nearby Eweburn Creek. At the same time 255 ha of the lease property was in permanent pasture of varying ages, 113 ha was in feed crops, 60 ha was in lucerne, 27 ha was fallow with the balance of the property (approximately 45 ha) covered in woodlots, shelter belts and unimproved riverbed adjacent to the Eweburn Creek.

Lismore has been set up to be a high producing sheep unit focused on the production of lambs. The property (in combination with the lease block) wintered 3,160 composite cross ewes which are expected to lamb at 150 %, 1015 hoggets that have been mated and which are expected to lamb at 85 %, and 300 boar goats (primarily for weed control) during 2003.

A distribution race from the Hawkdun Irrigation Scheme runs approximately down the middle of the property. Approximately 80 ha of the property has been set up for wild flood irrigation – although Mr Dowle suggested that only 20-30 ha of this area are effectively irrigated. According to the Hawkdun irrigation roster, Lismore is allocated 3 heads of water (85 ℓ/s) 4 days out of 15.

Mr Dowle has expressed concern regarding the wild flooding, as most of the paddocks are not fully irrigated, which makes feed and fertiliser management difficult. Historically, Lismore's stock water has been based around a series of ponds that were filled during wild flooding. Mr Dowle noted that during dry periods when the allocation was reduced, most of the roster water was used in filling the stock water ponds, thus leaving little to actually irrigate with. The Dowles have recently put in a pressurised trough-based stock water system that allows all the roster water to be used for irrigation.

## 3.1 Existing Irrigation Efficiency

As part of the project, monitoring was undertaken to determine current irrigation efficiency on Lismore. This monitoring was principally concerned with determining application efficiency, although the inclusion of pasture monitoring allowed production to be considered. Similarly, aerial photography of the property and discussions with the Dowles allowed whole farm irrigation efficiency to be considered. It is noted that similar monitoring of application efficiency was undertaken on the five representative farms in the Ida Valley, and the reader is referred to the Ida Valley report (Report No 4590/1) where irrigation efficiency is discussed in more details, and a comparison between the efficiency achieved by various irrigation methods (i.e. wild flooding, border-dyke, K Line and large guns) is given.

### 3.1.1 Application Efficiency

Application efficiency is defined as:

$$Application\ efficiency = \frac{Depth\ of\ water\ retained\ in\ the\ soil\ (mm)}{Depth\ of\ water\ applied} \times 100$$

Detailed monitoring was undertaken on the 11.5 ha Gums paddock on Lismore. The volume of water applied was measured using a flow recorder in the main race, with timer clocks on the turnout to determine the duration of watering. Soil moisture readings prior to and after irrigation were taken by Mr Dowle, using a HydroSence hand-held soil moisture probe. The soil moisture measurements were undertaken on a 50 by 100 m grid, resulting in a total of 26 measurements for the paddock.

The measurements indicated that there was considerable variation in the soil moisture content across the paddock, and highlighted that watering was far from even. Similarly, the monitoring highlighted how the paddock dried over the season as less water was available for irrigation (Figure 3 and Figure 4).

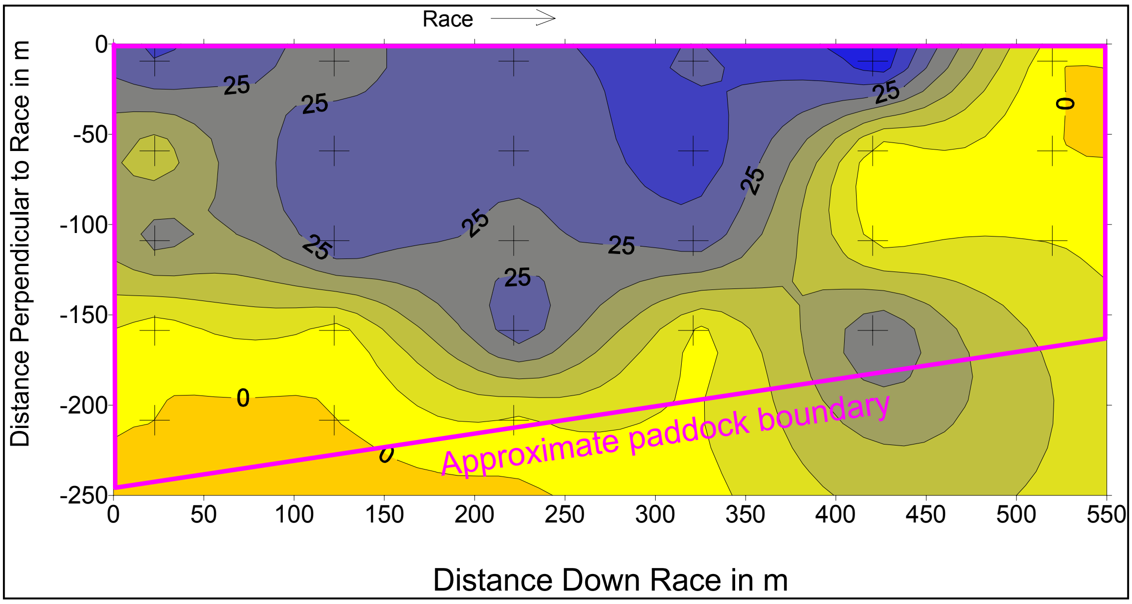



*Figure 3: Contour plot of change in soil moisture content measured during the 3 November 2002 irrigation of the Gums paddock*

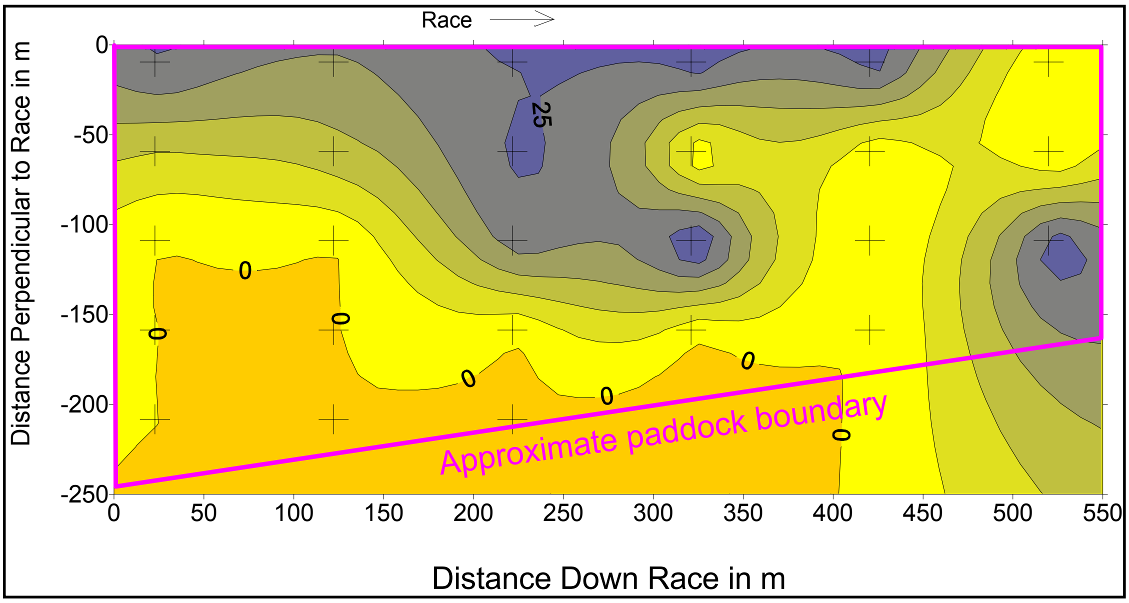



*Figure 4: Contour plot of change in soil moisture content measured during the 2 March 2003 irrigation of the Gums paddock*

A similar pattern was shown in the aerial photograph taken of the paddock in May 2003, although due to the paddock having seeded, the water pattern is difficult to discern (Figure 5). The paddock immediately downstream clearly highlights the varied nature of watering. From the aerial photos, it was estimated that of the paddocks that are wild flooded, at best, approximately 30% of each paddock was actually irrigated. A large proportion of the 30% irrigated consisted of low spots and gullies where over-watering was evident by the presence of surface ponds and rushes. It is noted that part of this over-watering is because Lismore stock water system had previously relied on using wild flooding to fill various stock water ponds.

Note the varied watering pattern in the downstream paddock, where water flows from the turnout near the trees down to a small pond. The thins lines of darker green flowing both down to and from the pond represent areas that have been over-watered and where significant drainage will be occurring.

The monitored paddock, the Gums. Note the differential watering pattern is less easy to see due to grass seeding.

*Figure 5: Aerial photo of the Gums paddock taken in May 2003, showing the differential watering pattern.*

Over the 2002-03 season, six irrigation events were monitored. Application efficiency varied form 50% to 86%, with an average of 73% (Table 3). This is considered high for wild flooding, and is partly explained by the fact that the application efficiency has been calculated by assuming that there is even watering over the area that is irrigated. In practice, this is not the case, as most of the water tends to flow along preferential paths (usually associated with formed contour ditches or natural depressions) and results in a significant amount of differential watering. Field observations over the season suggest that within the area wild flooded there were sections that achieved a very high application efficiency due predominantly to the high water-holding capacity of the soils and the long return periods between irrigations that allowed the soils to dry out considerably between irrigations. However, there were large areas where the application efficiency would have been well below that measured and where significant drainage (irrigation water that drains through the soil profile and is lost to the pasture) would have occurred. The occurrence of this over-watering is confirmed by the presence of rushes and ponds in the natural depressions in areas that are wild flooded.

*Table 3: Irrigation efficiencies calculated from wild flooding of the Gums paddock over the 2002-03 season*

| Irrigation event | Average flow | Duration of watering | Average soil moisture [1] | | Average depth applied [2] | Percentage of paddock irrigated [3] | Application efficiency [4] |
|---|---|---|---|---|---|---|---|
| | | | Before | After | | | |
| | (ℓ/s) | (h:min) | (%) | (%) | (mm) | (%) | (%) |
| 6.20 pm 3 Nov - 5.10 pm 4 Nov | 85 | 22:50 | 36 | 63 | 92 | 51 | 84 |
| 9.00 am 2 Dec - 6.50 pm 3 Dec | 62 | 33:50 | 26 | 53 | 90 | 55 | 82 |
| 11:10 am 1 Jan - 8:30 pm 2 Jan | 49 | 33:20 | 21 | 50 | 99 | 41 | 86 |
| 8:30 am 31 Jan - 2:00 pm 1 Feb | 55 | 29:30 | 26 | 48 | 73 | 43 | 68 |
| 12:30 pm 2 Mar - 11:50 am 4 Mar | 34 | 48:20 | 24 | 47 | 78 | 39 | 65 |
| 12:20 pm 3 Apr - 5:00 pm 4 Apr | 35 | 28:40 | 22 | 52 | 46 | 31 | 50 |
| **Average** | **53** | **32:45** | **26** | **52** | **80** | **43** | **73** |

Notes:

(1) Based on measurements from the HydroSense soil moisture probe using 120 mm long probes.

(2) Based on flow records and accounting for the areas irrigated.

(3) Based on dividing the paddock into 26 sections according to the location of the soil moisture measurements and assuming that the area irrigated represents those areas where soil moisture increased by greater than 5%.

(4) Assumes a 400 mm soil profile of Struan sandy loam with the depth of water stored calculated by assuming the probe measurements applies for the first 200 mm and 68% of the probe measurement applies for the lower 200 mm. The 68% value was calculated from work done by Cossens and Rickard in 1968.

### 3.1.2 Pasture Production

As part of a complimentary study undertaken by Karl Barclay from AgFirst Consultants Ltd, pasture production on the Gums paddock was also measured using pasture cages and a combination of pasture cuts and pasture probe measurements. The results indicated that from late November 2002 to early May 2003 the irrigated area of the Gums paddock grew 4,450 kg of dry matter per ha (kg DM/ha), at an average rate of 29 kg/ha/d (Table 4 and Figure 6). This is considered relatively low, as annual production figures of over 14,000 kg/ha at rates of up to 200 kg/d have been recorded for good grass species under well-fertilised, well-managed and well-watered irrigation in Canterbury. While the growing season is shorter than in Canterbury, the higher levels of solar radiation experienced in Central Otago are expected to result in similar production figures. The relatively low production figures measured are, in part, due to the fact that the prime grass growing months of October and November were not included. However, it is suspected that the low productions values are principally due to a lack of water, and that the pastures experienced significant periods of water stress. It is noted that, as part of the pasture studies, the pasture species was analysed and was found to contain 30% clover and 64% grass – a combination that, under the right conditions, can lead to a high level of production (although grass species is critical). By comparing production with water use, it was found that 11.5 kg DM/ha was grown for every millimetre of irrigation water applied, which is considered low, especially as it does not include allowance for rainfall. Although this is a similar figure to those measured by Cossens (1982) in studies undertaken throughout Central Otago in the 1960's and 1970's, it indicates that there has been little improvement in irrigation management in the ensuing years.

*Table 4: Production measured on the Gums paddock, November 2002 to May 2003*

| Period between pasture cuts (roughly 3 weeks) | Average daily production (kg DM/ha/d) | Water applied (mm) | Production per mm of water applied (kg DM/mm) |
|---|---|---|---|
| 28 Nov-19 Dec | 49.2 | 90 | |
| 19 Dec-12 Jan | 27.6 | 99 | |
| 12 Jan-3 Feb | 59.0 | 73 | |
| 3 Feb-24 Feb | 24.6 | 0 | |
| 24 Feb-17 Mar | 25.7 | 78 | |
| 17 Mar-3 Apr | 16.6 | 0 | |
| 3 Apr-5 May | 3.5 | 46 | |
| **Total 29 Nov-5 May** | **4,450** | **386** | **11.5** |

Pasture production varied throughout the year and, interestingly, there was a low spot in late December-early January before production peaked in mid to late January. It is expected that this variation is principally due to approximately 25 mm of rain that fell in early January 2003. This further confirms that production is currently being limited due to insufficient water.

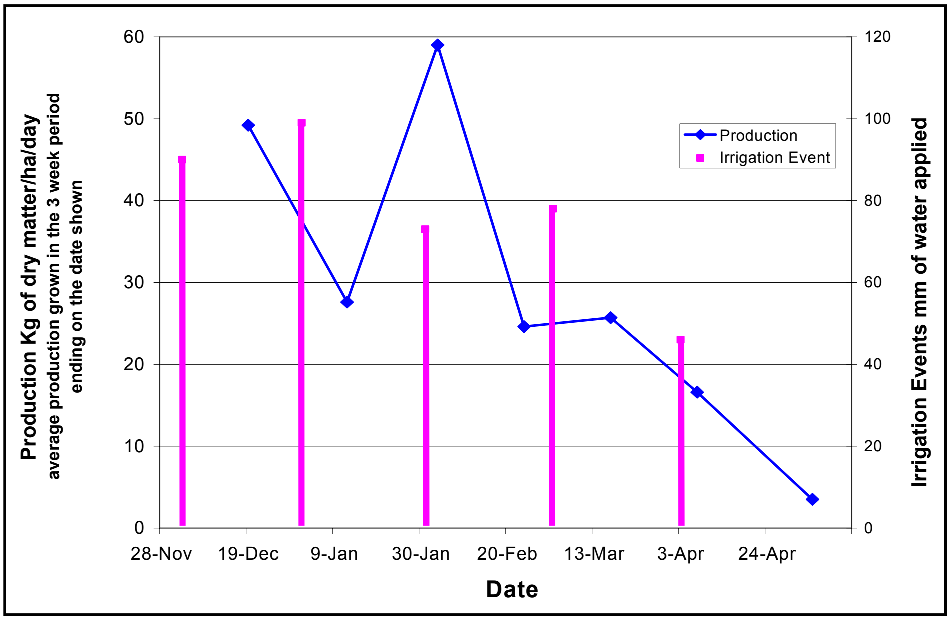



*Figure 6: Pasture production and irrigation measured on the Gums paddock (November 2002 to May 2003)*

### 3.1.3 Farm Irrigation Efficiency

As well as application efficiency and production, total or farm irrigation efficiency covers numerous other issues including economic, labour, energy use and stock health issue. While it was outside the project to consider many of these issues in detail, it was considered appropriate to make the following comments.

In regard to the labour requirement of the current wild flooding, Mr Dowle indicated that when he has water on his property (i.e. for 4 days out of 15), he spends approximately 2 hours per day shifting the water and ensuring that as wide an area as possible is irrigated. This equates to approximately 1 day per roster period, or two weeks over the irrigation season (mid September to end of April). In addition, there is time required to maintain structures and turnouts. Also, the numerous small ditches within the paddocks require maintenance and periodically need to be reformed to maintain water flow. This is significant when paddocks are worked, as the ditches and contour paths need to be reformed. It is noted that the differential watering, which results from wild flooding, creates challenges for fertiliser and feed management that can lead to extra time and inefficiencies (e.g. the difficulties associated with fertilising half-watered paddocks).

Energy use is essentially zero with the current wild flooding system, as there is no pumping involved.

As outlined above, while Lismore is set up to irrigate approximately 80 ha using wild flooding, Mr Dowle considers that only 20-30 ha is irrigated properly. Results from the monitored paddock highlight this (i.e. while the paddock is 11.5 ha in size, only 30% or 3.5 ha actually received water for the whole 2002-03 season). Aerial photographs undertaken at the end of the 2002-03 irrigation season indicted that none of the paddocks that were irrigated received much more than a 30% water cover. Figure 7 highlights the patchy nature of the existing wild flooding, and indicates that there are many areas that are being over-watered.

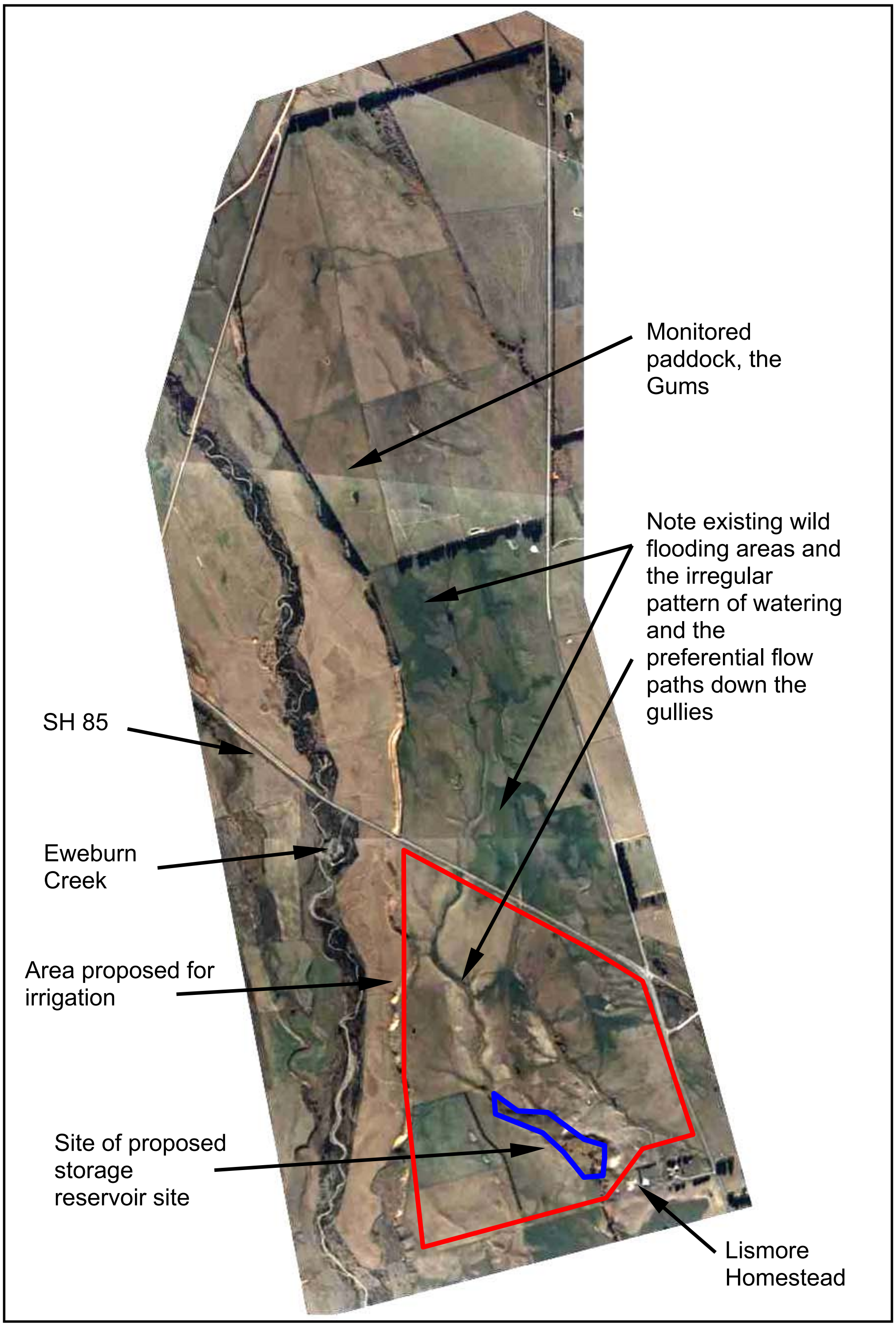



*Figure 7: Aerial photograph of Lismore taken in early May 2003 showing the irrigated areas*

# 4 WATER SUPPLY

As outlined above, a distribution race from the Hawkdun Irrigation Scheme runs approximately down the middle of the property. Numerous turnouts are situated within the race, allowing approximately 80 ha of the property to be wild flooded. According to the scheme roster, Lismore is allocated 3 heads of water (85 ℓ/s) 4 days out of 15. When wild flooding, it has been usual practice to direct the full flow (up to 3 heads) through one turnout.

Flow in the main race was monitored from 12 November 2002 to 5 May 2003, using a rectangular weir and a capacitance water level probe (Figure 8). The capacitance probe has an accuracy of ±2 mm, which equates to an accuracy in the flow measurements of approximately ±5%. The principal reason for monitoring flow in the race was to allow application efficiency to be calculated on the Gums paddock, as outlined above. However, the monitoring allowed the water supply to the property to be assessed in detail.

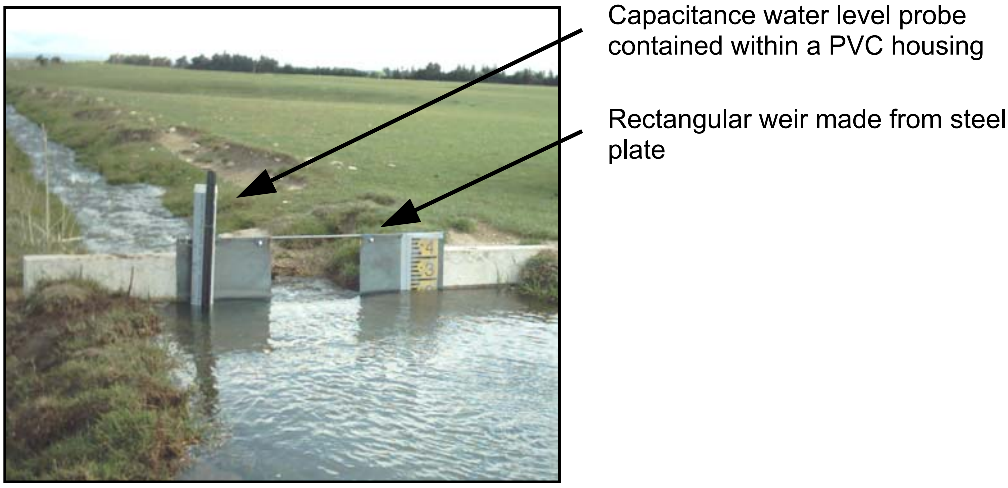



*Figure 8: Lismore flow measurement site in the distribution race of the Hawkdun Irrigation Scheme*

Monitoring over the 2002-2003 irrigation season revealed that flow in the race varied significantly. For most of the season, the flow in the race was significantly less than the 85 ℓ/s (3 head) allocation (Table 5 and Figure 9).

*Table 5: Average flows recorded in the irrigation race at Lismore farm over the 2002-2003 irrigation season*

| Month | Number of days flow recorded on Lismore | Average daily flow for the month (ℓ/s) |
|---|---|---|
| Nov 2002 | 13 | 69 |
| Dec 2002 | 24 | 64 |
| Jan 2003 | 25 | 58 |
| Feb 2003 | 25 | 57 |
| Mar 2003 | 22 | 30 |
| Apr 2003 | 25 | 35 |
| May 2003 | 2 | 41 |
| Average flow Nov-April | | 52 |

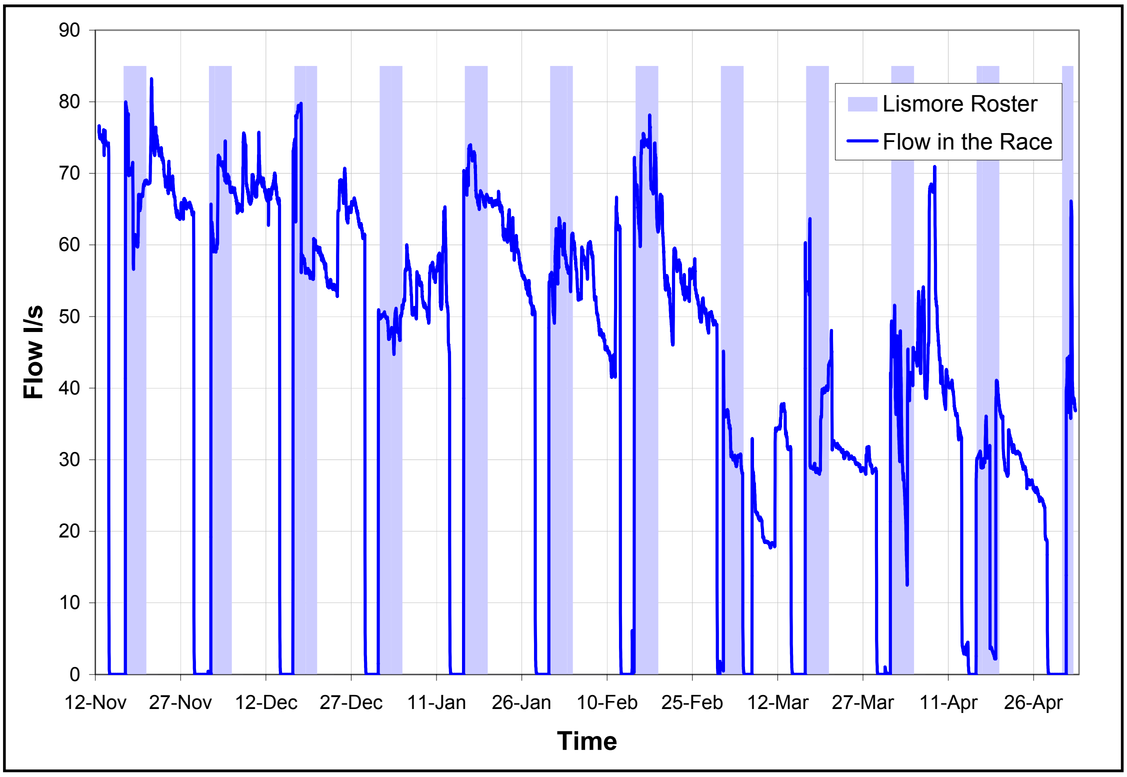



*Figure 9: Flow in the Hawkdun Irrigation Scheme's distribution race at Lismore from 12 November 2002 to 3 May 2003*

## 4.1 Flow Reliability

The Hawkdun Irrigation Scheme, as a run-of-river take, is subject to low flow restrictions and frequently, during the summer, the Scheme cannot abstract its full allocation. The lack of reliability of river flow is compounded by the fact that the Scheme has 108 km of main race and a further 194 km of distribution race, much of which is very old and distribution losses are expected to be significant. Flow measurements over the 2002-2003 irrigation season indicated that the flow varied significantly from month to month and, at no point, did the flow supplied to Lismore reach the design flow of the existing scheme (3 heads or 85 ℓ/s at Lismore). The average monthly flows recorded are summarised in Table 5 above. The variable nature of the Scheme and the lack of reliability of water supply make it extremely difficult to manage irrigation on Lismore. To overcome this, it is proposed to create a storage reservoir to act as a buffer and to allow a constant amount of water to be fed into the on-farm irrigation network.

Water management on the Hawkdun Irrigation Scheme is based on a fixed roster, whereby properties are supplied with water for a certain number of days per roster period, irrespective of whether or not the water is needed. Providing storage will allow Lismore to more efficiently manage its water allocation. During periods when soil moisture levels are naturally high due to rainfall, water will be able to be stored rather than being essentially wasted by irrigating already wet paddocks. Likewise, by filling the storage during periods of low demand (i.e. the late autumn and early spring), Lismore will be able to increase the volume of water it has available for irrigation. A preliminary report covering the design of the storage was produced in July 2003, and is attached in Appendix 1. The preliminary report was produced early to enable the Dowles to begin the process of obtaining the necessary resourse consent required in order to construct the reservoir. It is noted that the topography of the Lismore farm does not lend itself to the easy construction of a large reservoir. However, a site was found that could store 85,000 $m^3$, which represents three complete rosters worth of water. The details of the storage dam are outlined in the preliminary report.

# 5 POTENTIALLY IRRIGABLE AREA

The irrigation model predicted that, for optimum irrigation, a system capacity of 0.4 ℓ/s/ha was required, with an optimum return period of 13 days. Such irrigation would result in optimum grass growth, as the pasture would never be under significant water stress. To determine the area potentially irrigated, the volume of water in the reservoir has been modelled based on the inflows measured during the 2002-2003 season (Table 6) and the irrigation demand determined from the irrigation model (based on spray irrigation, applying 45 mm with a minimum rotation of 13 days, and using climate data from Ranfurly from 1975-88 and 2001-03). The modelling indicates that the reservoir will easily fill every season, and can fully irrigate 50 ha with very few periods when irrigation demand cannot be met (Figure 10).

*Table 6: Average daily flows in the irrigation race at Lismore*

| Month | Average daily flow measured 2002-03 (ℓ/s) | Average daily flow used to predict inflow into the Lismore storage reservoir (ℓ/s) |
|---|---|---|
| January | 58 | 55 |
| February | 57 | 55 |
| March | 30 | 30 |
| April | 35 | 35 |
| May | 41* | 40 |
| June | ** | 0 |
| July | ** | 0 |
| August | ** | 50 |
| September | ** | 70 |
| October | ** | 70 |
| November | 69* | 65 |
| December | 64 | 65 |
| **Average Nov-Apr** | **52** | **51** |
| **Average annual** | | **45** |

Notes:
* Only part of the month measured – 2 days in May and 13 days in November
** Flow not monitored

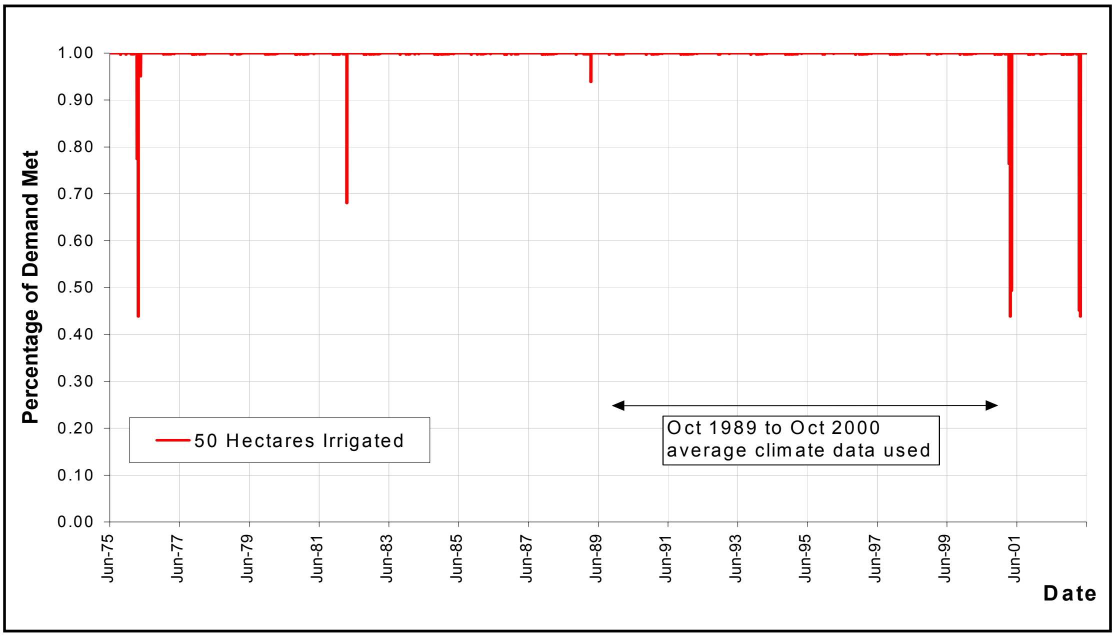



*Figure 10: Reliability of water supply when irrigating 50 ha from the proposed reservoir*

Raising the area irrigated to 70 ha will result in the dam emptying every year (1975-88 and 2001-03), and there will be occasions during most years when only 50% of the irrigation demand can be met (Figure 11). Given that the objective of the storage reservoir is to drain it every year, it is recommended that the system be designed to irrigate no more than 70 ha. Irrigating 70 ha would result in an annual application depth of 495 mm (assuming that the full capacity of the dam plus all the inflow from 1 October to the end of April is evenly applied over the 70 ha), which is consistent with the results predicted by the model.

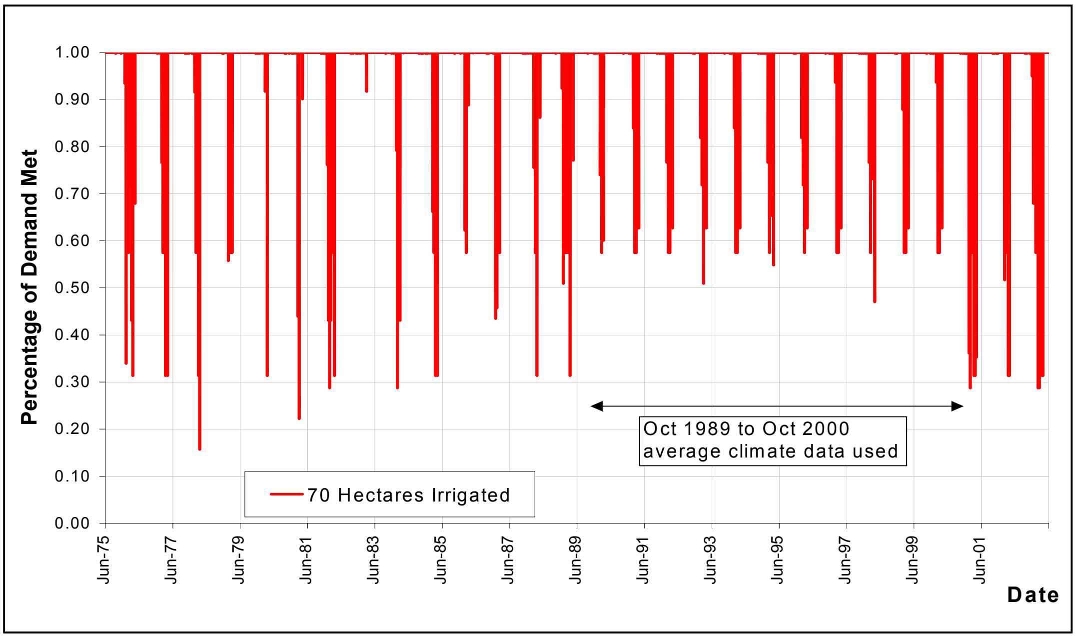



*Figure 11: Reliability of water supply when irrigating 70 ha from the proposed reservoir*

Discussions with the Dowles indicated that they wish to spread the water more thinly, and asked for the system to be designed for 90 ha, which represents essentially all the irrigable land below State Highway 85. Irrigating 90 ha results in the reservoir regularly emptying and substantial periods each year when full irrigation demand cannot be met (Figure 12).

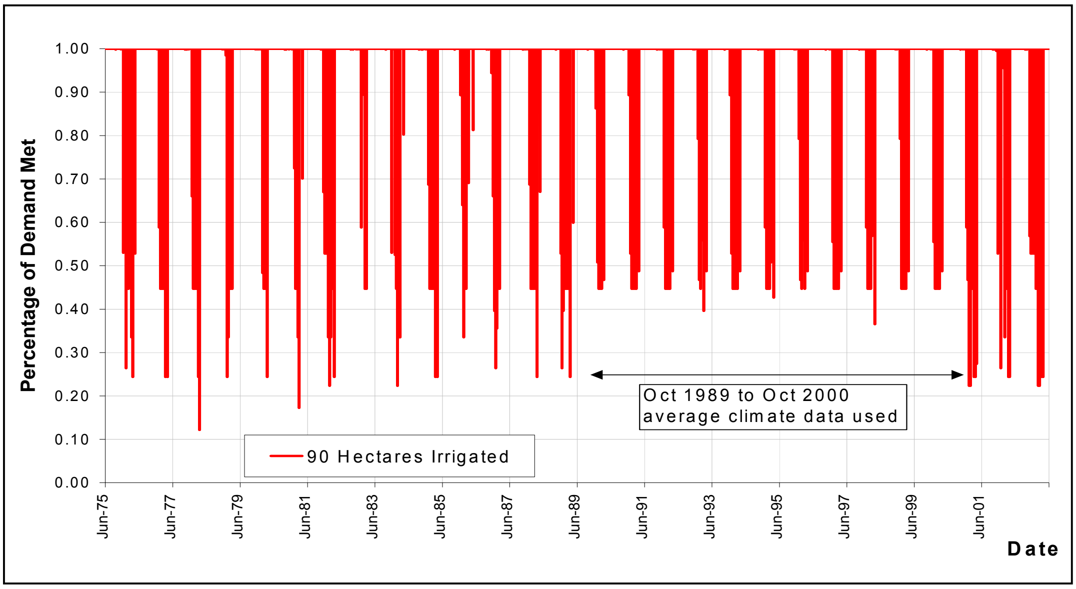



*Figure 12: Reliability of water supply when irrigating 90 ha from the proposed reservoir*

Irrigating 90 ha would result in an annual application depth of only 385 mm (assuming that the full capacity of the dam plus all the inflow from 1 October to the end of April is evenly applied over the 90 ha). An annual application depth of

385 mm is considered low (well below the 490 mm that the modelling work suggests is optimal), and which we expect will result in reduced production at the height of the season due to the grass being under moisture stress. The modelling is based on flow measured over the 2002-03 season, which Mr Dowle indicated was a particularly bad one in terms of water availability. It is noted that if the reliability of the Hawkdun Irrigation Scheme could be improved so that Lismore received its full quota (3 heads, 4 days out of 15), then there would be potential to irrigate up to 100 ha with the storage reservoir.

The reservoir will operate by being filled from the Scheme during periods when the water is not required for irrigation – namely at the start (August-September) and end of the season (April-May). It is noted that even when irrigating 90 ha, the dam will easily fill every year (based on climate data from 1975-88 and 2000-03). Figure 13 provides an indication on how the volume of water in the reservoir will change over time.

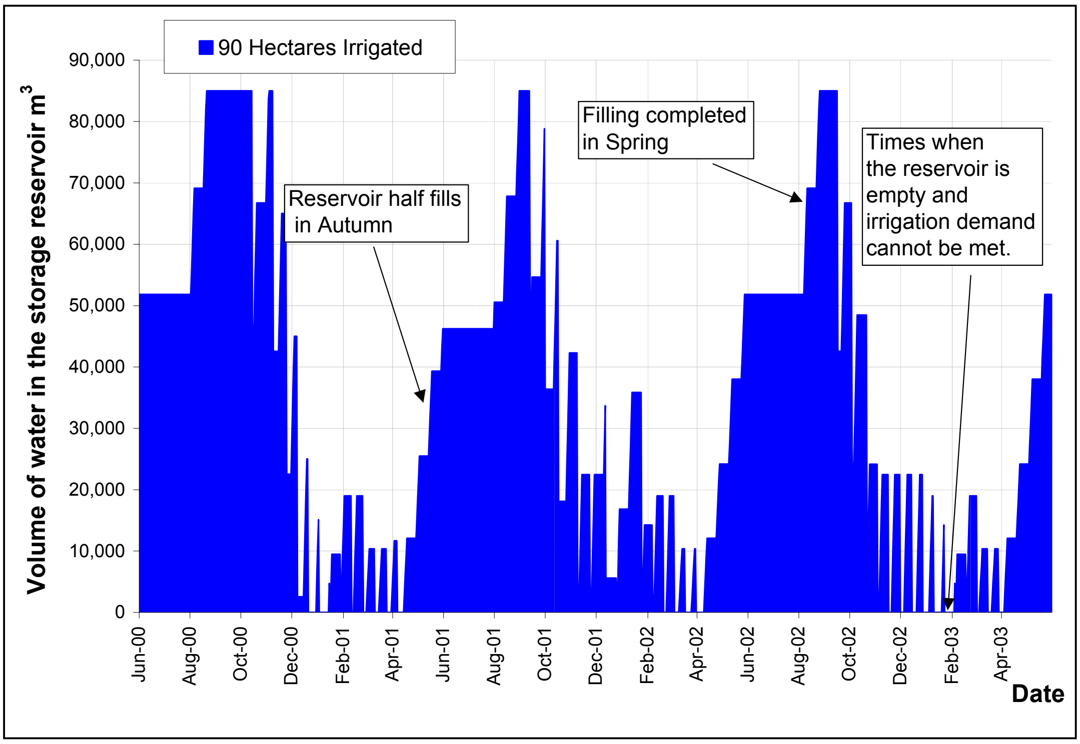



*Figure 13: Volume of water in the Lismore storage when irrigating 90 ha (based on climate date from June 2000 to May 2003)*

Mr Dowle indicated that he would manage the periods of unmet demand by reducing the area irrigated (i.e. by dropping off paddocks). He expects part of the area irrigated to be in annual feed crops (which, because of their greater rooting depth, require less watering than pasture). It is noted that feed crops (namely turnips and swedes) are successfully grown under dryland conditions in the Ranfurly area. As such, Mr Dowle expects to be able to discontinue watering once the crop is established, which will enable him to drop off paddocks and reduce the area irrigated.

The soils of the Maniototo Basin are generally brown-grey and yellow grey earths, which have reasonable water-holding capacity (i.e. can store a reasonable volume of water), but which are generally quite tight and have low infiltration rates. Applying large amounts of water quickly tends to result in ponding and surface runoff. The challenge to irrigators is to either apply small amounts of water very regularly, or to use a method that applies a reasonable amount of water (say, 40-60 mm) in a manner that allows sufficient time for infiltration. It is noted that recently a number of farmers have moved away from large, high application rate irrigators (i.e. Roto-Rainers and large guns) to methods that apply similar volumes but over a longer period (i.e. K Line).

The modelling predicted an optimum rotation period of 13 days. To allow a regular weekly pattern to be established, a 2-week rotation was used in the subsequent irrigation designs.

# 6 TARGET AREAS

As outlined above, any future irrigation development on Lismore will require the construction of the proposed storage reservoir. As such, the location of the reservoir has a strong influence over which areas should be irrigated. Unfortunately, due to topography, the reservoir is located near the downstream boundary of Lismore, which requires pumping from the reservoir. In order to minimise the pumping costs, the areas closest to the reservoir will be targeted for irrigation (i.e. all the area below where SH 85 crosses the property). The soils in this area are Becks sandy loams, which have a higher water-holding capacity than the Naseby and Struan sandy loams that cover other parts of Lismore. Designing the irrigation to target the higher water-holding capacity soil is appropriate, as it will mean that larger amounts of water can be applied and, therefore, a longer return interval used.

The only disadvantage of the area below SH 85 is that the topography is broken by two gullies (one of which will be filled by the proposed reservoir), which will limit the type of irrigator that can be used. Also, there are a number of existing shelter belts in the block that Mr Dowle would prefer not to remove, as trees are particularly hard to grow in the area. It is noted that if lack of water is the reason for the difficulty in growing shelter any irrigation system could easily be designed to trickle irrigate new shelter belts.

# 7 FUTURE IRRIGATION DEVELOPMENT

A major focus of the project has been the development of plans for future irrigation on the property. As such, three options for irrigation development were produced. In doing this, it was anticipated that the recommendations made for Lismore would be transferable to other similar farms in the area. It is noted that a similar process was undertaken in the Ida Valley as part of a bigger project.

Prior to describing the three development options, it is considered appropriate to make a number of comments on how Lismore could, with relatively little expense, improve the current wild flooding.

## 7.1 Improving Current Irrigation Practice

Up to approximately 80 ha of the Lismore property is currently wild flooded, using numerous turnouts from a distribution race of the Hawkdun Irrigation Scheme that runs down the centre of the property. As outlined earlier, the unreliable nature of the Scheme means that it is very difficult to effectively manage irrigation, as inflow to the property is continually changing. The current practice of using all the available flow through one turnout at a time is endorsed, as work undertaken on border-dykes in the Ida Valley that have similar soils to those at Lismore suggested that greater application efficiencies are achieved by using higher flow rates for shorter times. Similarly, the recent installation of a piped stock water scheme will greatly improve water use. The use of wild flooding to fill stock water ponds is considered very inefficient in that a far greater amount of water is stored in the ponds than is required by the stock, and significant over-watering is expected on the channels that lead to the ponds. Where possible, the existing irrigation water should be directed to areas of Becks soil rather than the Struan or Naseby soils, as the Becks soils have a higher water-holding capacity. Also, paddocks that have an even contour should be preferred over paddocks with ponds or gullies, as depressions act as preferential flow paths and cause over-watering.

In scheduling the watering, it is suggested that the water should be spread as far as possible during the shoulders of the season (i.e. spring and particularly autumn), but during the main season (summer), watering should focus on a smaller area to ensure it is appropriately watered. The current 15-day roster for the Hawkdun Irrigation Scheme is considered appropriate, as it prevents the soil from drying out too much between watering. Increasing the rotation to greater than 15 days is not supported, as it would lead to the development of significant moisture stress, which would limit production. As such, particularly during the peak of the season, the area selected on Lismore for irrigation should be irrigated every rotation. Trying to increase the area irrigated by irrigating half the area this rotation and then the other half next time is not supported, as production will be significantly reduced due to moisture stress. It is noted that the most important irrigation for spring growth is the last one in the proceeding autumn, as this 'sets up' the roots for the following spring. As such, during the last watering of the season, the water should be spread as far as possible to ensure as great an area as possible is 'set up' for spring.

Providing the correct amount of water at the correct time is only one of the many key ingredients required to maximise production. Pasture species, fertiliser rates, and grazing management all play a significant part and need to be considered equally when irrigating. As such, watering either unimproved native grasses or old grass species with insufficient fertiliser input will not maximise the benefit of the irrigation.

## 7.2 Selection of the Three Methods

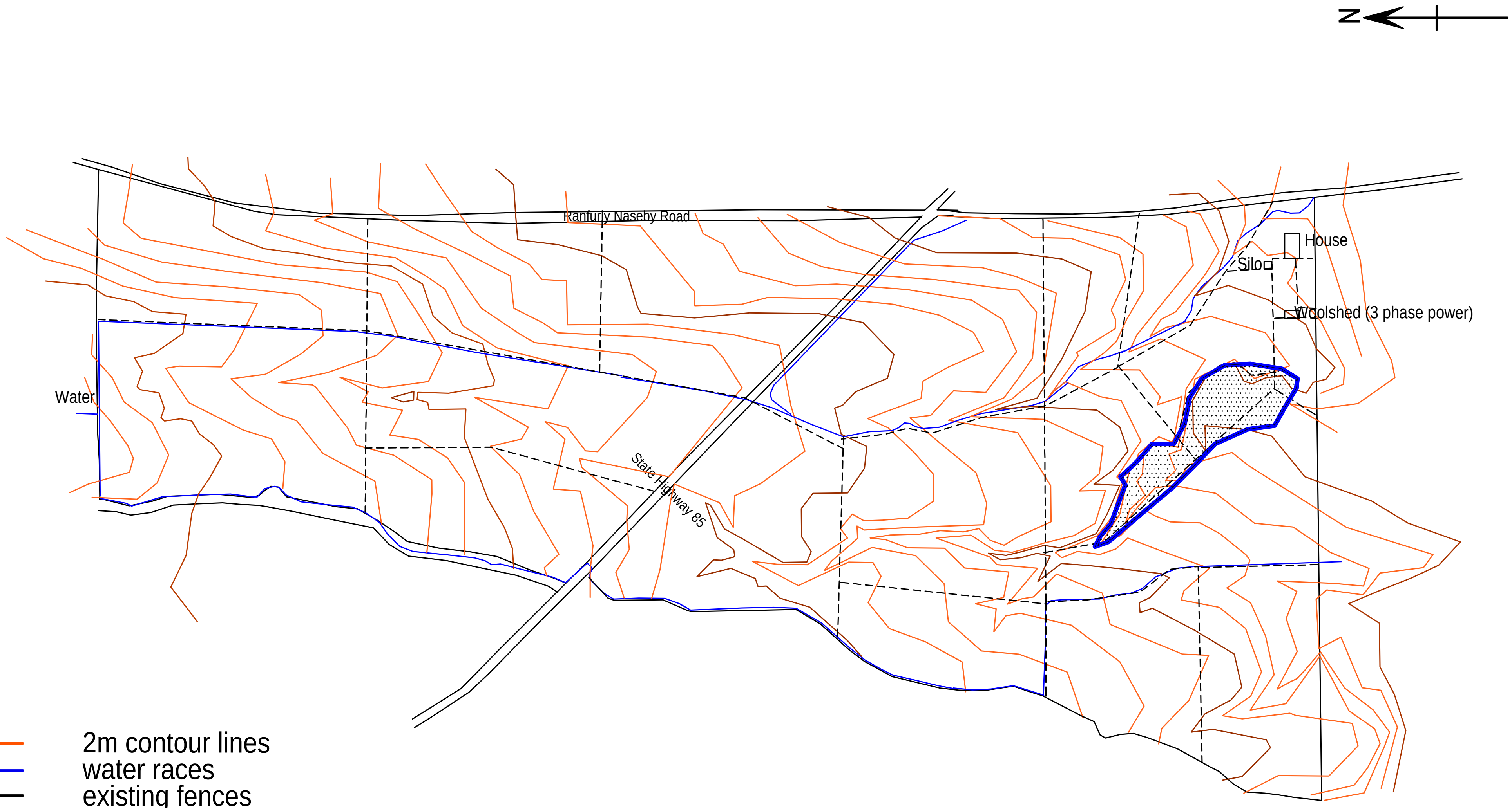
In selecting the three irrigation methods for Lismore, the following key points have been considered:

- The topography of the area to be irrigated and particularly the presence of the proposed reservoir, which is essentially in the middle of the area.
- The water-holding capacity of the soils, which at 90 mm for Becks sandy loams suggests a maximum application depth of 45 mm or half the water-holding capacity.
- The tightness of the soils that results in low infiltration rates and requires that water is applied at a low rate.
- The difficulty in growing shelter in the Ranfurly area, which requires that the existing shelter belts are preserved as much as possible.
- The likely end use for the irrigated area, which Mr Dowle has indicated is likely to be an intensive sheep fattening unit and the need for races etc.
- The labour requirement as the Dowles essentially farm the block alone.

As well as the above points, discussion with the Dowles indicated that they favoured K Line and other similar irrigation methods. As such, the following three methods have been selected:

- Two K Line based systems – one using the standard K Line system, and another using Ezi rain
- A hybrid system using K Lines and a Roto-Rainer

It is noted that the topography of the area (a 28 m height difference) and the location of the reservoir (situated at the bottom of the area) means that differential pressures will occur throughout the block; this will have implications on any irrigator used, and will require pressure control for various sections of the area (Figure 14).




Key

- 2m contour lines
- water races
- existing fences
- existing roads
- proposed storage reservoir

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# Contour Map

## Lismore Farm
## Hawkdun Irrigation Scheme

| | |
|---|---|
| Designer: | Lincoln Environmental |
| Date: | August 2003 |
| Scale: | 1 : 12500 |

## 7.3 Plan 1 – K Line System

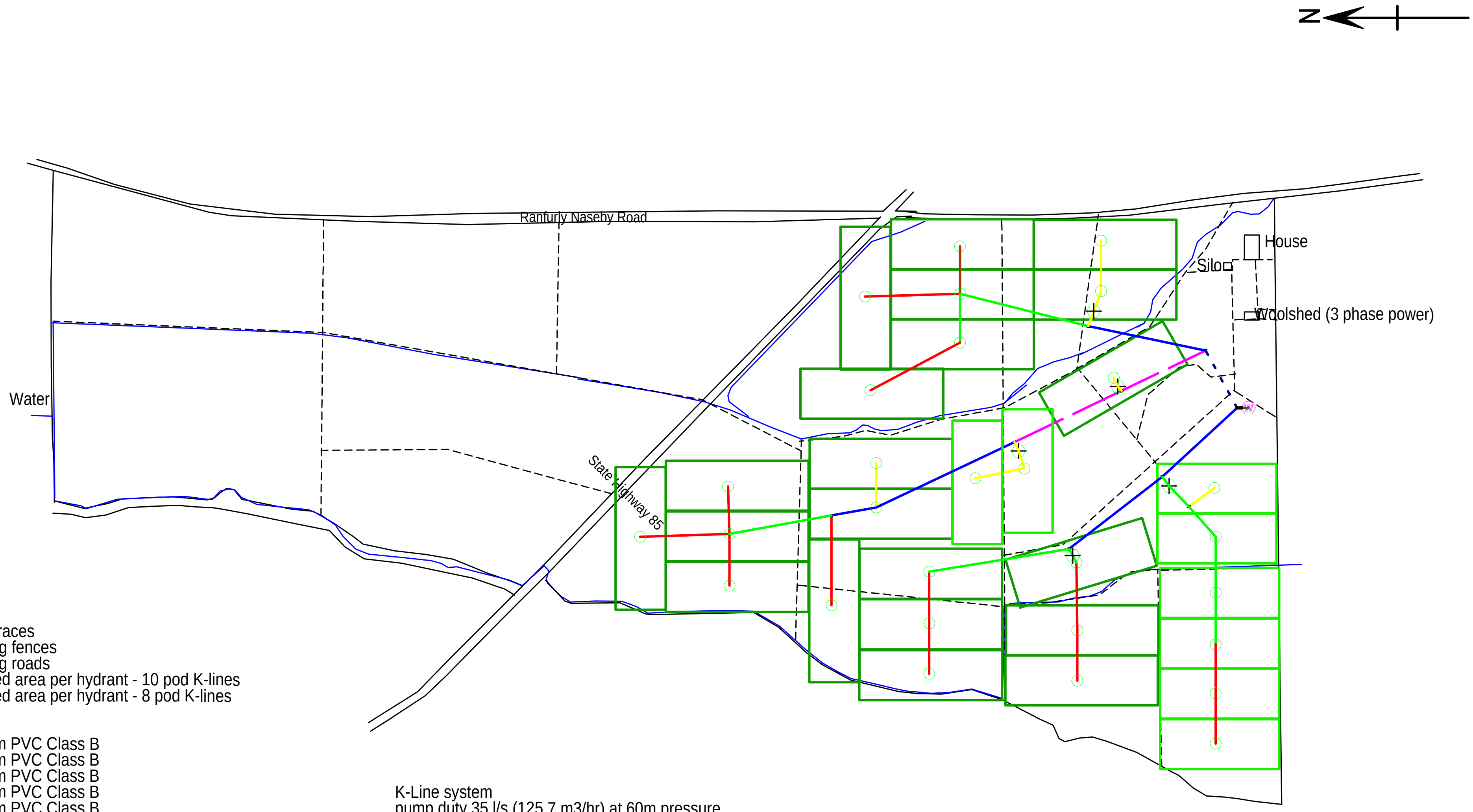
### 7.3.1 System Description

Essentially, a standard K Line system is used to irrigate as much of the area below SH 85 as possible up to a maximum of 90 ha. The system is based around using 10-pod K Lines with 15 m shifts on a 14-day rotation. As such, each K Line will water 3.15 ha. The K Line length has been limited to 10 pods to reduce the pressure differences down each line. Where possible, the K Lines have been run parallel to the contour. To make shifting easier, each of the K Lines has been designed to fit within a rectangular 300 m by 105 m watered area. Also, limiting the K Line length to 10 pods will greatly assist shifting, especially on the more undulating sections of the block. The system has been designed to work with existing shelter belts and the existing water supply race, although re-fencing will be required.

As outlined in Figure 15, the proposed plan consists of 29 K Lines, 21 of which have 10 pods, with the remaining having 8 pods. A total of 88 ha will be irrigated. Assuming that the K Lines run continuously for 24 hours a day, 2 mm nozzles will apply 49 mm of water, which is slightly over the desired application depth of 45 mm (which represents 50% of the water-holding capacity of the Becks soil). It is anticipated that 2 mm nozzles will cause problems with blockage etc., especially as the water will be coming from the reservoir and is likely to contain algae etc. It is, therefore, recommended that at least 2.5 mm nozzles (or preferably 2.8 mm nozzles) be used. To prevent over-watering with the larger nozzles, the watering time will need to be reduced to 18-20 hours for the 2.5 mm nozzles and 16-18 hours for the 2.8 mm nozzles. Reducing the watering time provides plenty of time to shift the lines when they are empty, plus there is the ability to apply more water at the height of the season if required.

For the given design, a pump that can supply 35 ℓ/s at 60 m pressure will be required. It is suggested that a Southern Cross 100×65-200 pump, with a 218 mm impeller attached to a 30 kW motor or an equivalent pump, would be appropriate. This is a high-speed pump that runs at 2920 rpm, and has an efficiency of approximately 80%. It is suggested that the pump be placed immediately below the dam wall at an elevation such that the pump is below the outlet pipe from the dam. This will ensure that there is always positive pressure on the suction side of the pump, and allows the use of a high-speed pump, which is more efficient than a lower speed pump. A 3-phase power supply will be required at the pump shed.

The pipe network has been designed so that Class B PVC pipe can be used throughout. The design criterion has been to supply all the hydrants with 32 m of pressure. The topography and the need to keep maximum pressures under 60 m results in the pipes being designed to minimise friction losses. This causes many of the pipes to be larger than would normally be required for a low-pressure K Line system. The maximum pipe velocities is only 1 m/s, with most velocities approximately 0.5 m/s. The pipe layout has been designed as a branching network to minimise pipe diameters.




Key

- water races
- existing fences
- existing roads
- irrigated area per hydrant - 10 pod K-lines
- irrigated area per hydrant - 8 pod K-lines

mainline pipes

- 200mm PVC Class B
- 175mm PVC Class B
- 150mm PVC Class B
- 125mm PVC Class B
- 100mm PVC Class B
- 80mm PVC Class B
- 65mm PVC Class B
- 50mm PVC Class B
- hydrant
- water supply and pump

K-Line system
pump duty 35 l/s (125.7 m3/hr) at 60m pressure
29 K-lines, 8 with 8 pods and 21 with 10 pods
14 shifts per rotation
87.8 ha irrigated, 2.6ha for each of the 8 pod lines and 3.2ha for the 10 pod lines
for 24 hr watering 49mm applied, using 2mm nozels
for 23 hr watering 46mm applied, wusing 2mm nozels

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# Irrigation Design - K-Line

## Lismore Farm
## Hawkdun Irrigation Scheme

| | |
|---|---|
| Designer: | Lincoln Environmental |
| Date: | August 2003 |
| Scale: | 1 : 12500 |

The topography of the block results in pressure control being required at a number of hydrants. This can either be achieved at the relative hydrants or within the mainline pipes. Similarly on the spray lines where there is significant topography pressure control may be required on the individual sprinklers. As with all K Line systems, it is anticipated that on-site refinement of the design will be required to ensure that the water is applied evenly. As outlined in Table 7, there is a 12.7 m pressure difference between the lowest pressure hydrant (at the top of the block near SH 85) and the highest pressure hydrant (near the dam). Similarly, within the areas irrigated from a particular hydrant, there is up to a maximum of 8 m from the lowest point to the highest, although most blocks have been designed to limit this variation to less than 4 m. Additional work will be required to determine how best to cater for these pressure differences, (i.e. mainline pressure control, hydrant pressure control or pressure control at the sprinkler). It is noted that if these pressure variations are not accounted for it will result in differential watering both within each block and from hydrant to hydrant.

*Table 7: Hydrant pressure for K Line design*

| Situation at the hydrant | Pressure (m) |
|---|---|
| Lowest pressure | 28.9 |
| Highest Pressure | 41.6 |
| Average pressure | 34.8 |

### 7.3.2 Water Supply Details

As previously described, water supply to Lismore is from the Hawkdun Irrigation Scheme. The proposed reservoir will increase the reliability of the water supply. A 250 mm diameter pipe will feed out of the dam and connect to the suction side of the pump.

### 7.3.3 Irrigation Operation and Management

As outlined above, the system will be run from between 16 and 24 hours a day, depending on the size of the nozzles used. Shifting of 29 K Lines is expected to take approximately 3 minutes each, or about 1½ hours per day. Operation is expected to be relatively straightforward, and can be set up on a timer so that the pump switches on and off at a certain time each day. As with all irrigation systems, routine maintenance will be required from time to time (e.g. greasing the pump, cleaning filters etc.).

## 7.4 Plan 2 – Ezi rain Design

### 7.4.1 System Description

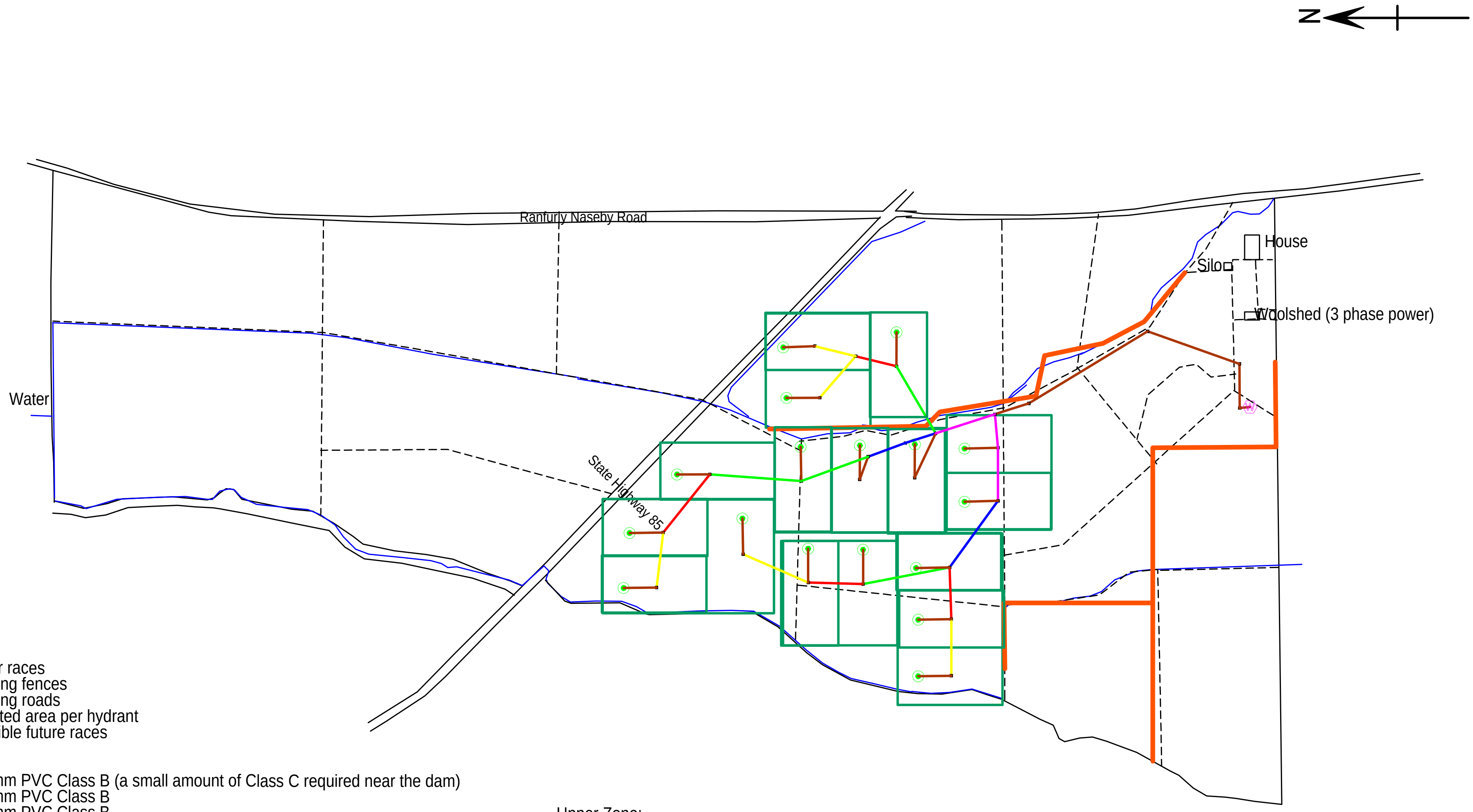
The Ezi rain system, developed and marketed by Water Dynamics, is a relatively recent addition to the irrigation market, and uses technologies from both K Line and long laterals. The system is based on small brass sprinklers (similar to a Nann 4.4×2.5), which are situated on metal plates. Like K Line, a series of sprinklers are joined together to form a line that is towed from position to position around the paddock. Ezi rain uses larger sprinklers and, therefore, requires fewer sprinklers per area; it is claimed to provide more even water coverage than traditional K Line.

The design is based on using the Ezi rain system to irrigate as much of the area below SH 85 as possible. The system uses 36 Ezi rain sprinkler lines to irrigate 95 ha, using a combination of three, five and six sprinklers at 25 m spacing per line, and 20 m shifts on a 10-day rotation. Each of the five sprinkler Ezi rain lines will water 2.64 ha. The line length has been limited to a maximum of six sprinklers to facilitate shifting and to reduce pressure losses. Where possible, the lines have been run parallel to the contour. To make shifting easier, each of the lines has been designed to fit within a rectangular 220 m by 120 m watered area (for the five sprinkler lines). The system has been designed to work with existing shelter belts and the existing water supply race, although re-fencing will be required.

As outlined in Figure 16 and Figure 17, the proposed plan consists of 36 Ezi-rain lines, 26 of which have five sprinklers, six lines have six sprinklers, and the remaining four have three sprinklers. A total of 95 ha are irrigated. The Ezi rain system is designed for 12-hour watering, and usually two blocks are established so that water can be continued for 24 hours (12 hours on one block and 12 on the other). Assuming that the lines run for 12 hours a day, the 4.4 × 2.5 nozzles will apply 38 mm of water, which is slightly less than the desired application depth of 45 mm (which represents 50% of the water-holding capacity of the Becks soil), and hence the rotation has been reduced to 10 days. The larger nozzles of the Ezi rain are not expected to have any problem with blockage. One of the advantages of the system is that there is capacity to increase the application depth considerable by simply extending the watering period. This can be particularly useful in the height of the season.

For the given design, a pump that can supply 41.3 ℓ/s at 60 m pressure and 37.8 ℓ/s at 65 m pressure will be required. Again, a Southern Cross 100×65-200 pump, with a 218 mm impeller attached to a 30 kW motor, would be appropriate, although it is noted that the motor will be at its upper limit and a slightly larger motor would be preferable (say 35 kW). As for the K Line design, a high-speed pump should be used (2,900 rpm), and should be placed immediately below the dam wall at an elevation such that the pump is below the outlet pipe from the dam. A 3-phase power supply will be required at the pump shed.

The pipe network has been designed so that Class B PVC pipe can be used throughout; although it is noted that a small section of Class C pipe will be required near the pump to handle the 65 m pump lift needed when irrigating the upper block. The design criterion has been to supply all the hydrants with 32 m of pressure. The topography and the need to keep maximum pressures under 60 m results in the pipes being designed to minimise friction losses. This causes many of the pipes to be larger than would normally be required for a low pressure system. The maximum pipe velocities vary significantly – in the lower sections where there is a need to burn off head, high velocities are encouraged, while in the upper section where head needs to be maintained, low velocities of less than 1 m/s are used. The maximum velocity is 2.1 m/s, which is considered high. The high velocities occur in small feeder lines near the bottom of the lower section. It is noted that these high velocities could be avoided by using pressure reducing valves. The pipe layout has been designed as a branching network to minimise pipe diameters.




Key
- water races
- existing fences
- existing roads
- irrigated area per hydrant
- possible future races

mainline pipes
- 200mm PVC Class B (a small amount of Class C required near the dam)
- 175mm PVC Class B
- 150mm PVC Class B
- 125mm PVC Class B
- 100mm PVC Class B
- 80mm PVC Class B
- 65mm PVC Class B
- 63mm low density poly pipe feed line
- hydrant
- water supply and pump

Upper Zone:
Pump duty 136 m3/hr (37.8 l/s) at 65m head
17 Ezi-rain sprinkler lines 5 sprinklers at 25m spacing per line
10 shifts per rotation
2.6ha irrigated per sprinkler line
for 12 hour watering 38mm applied
Note pressure reduction may be required on some of the lines

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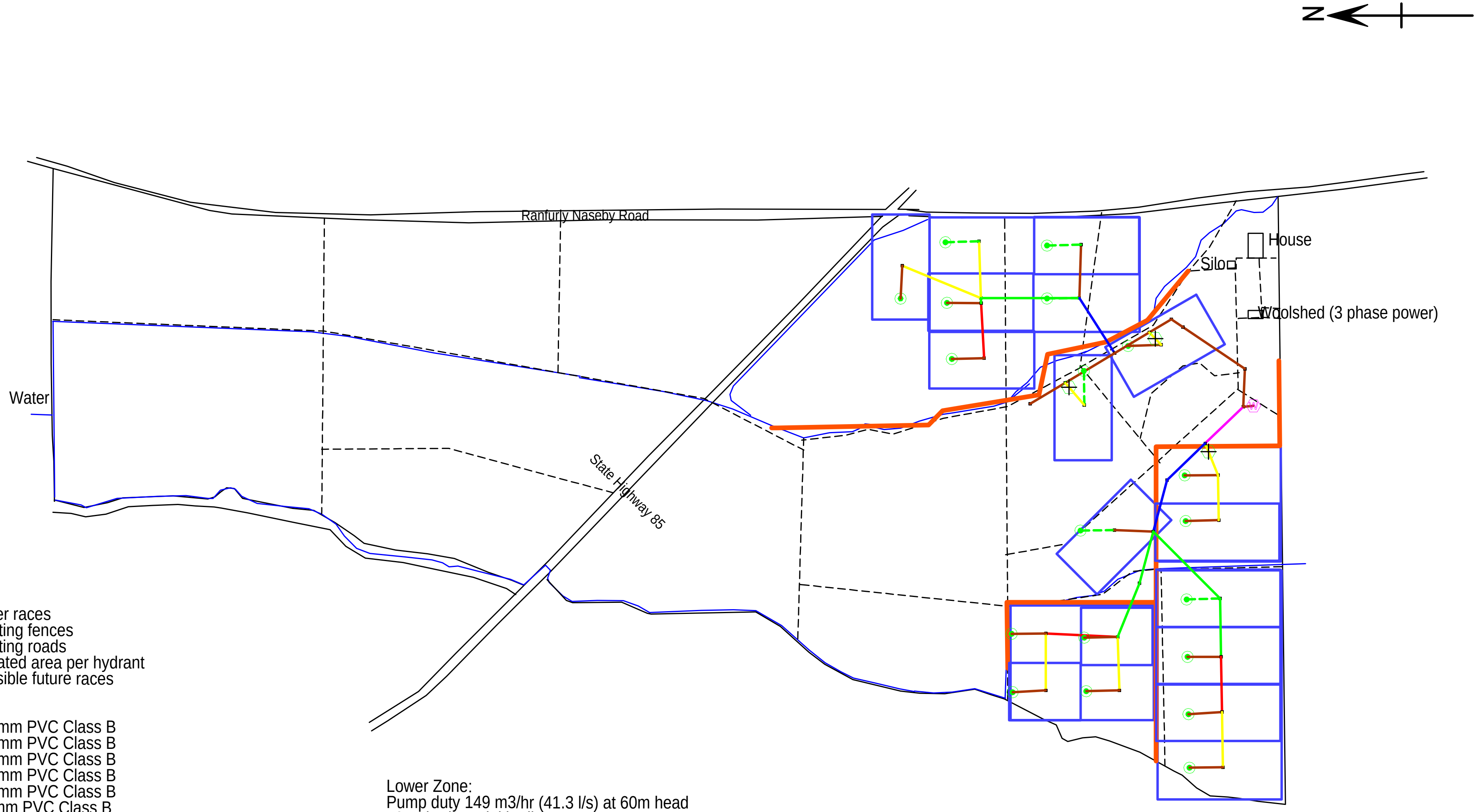
# Irrigation Design
# Ezi-rain upper section

# Lismore Farm
# Hawkdun Irrigation Scheme

| | |
|---|---|
| Designer: | Lincoln Environmental |
| Date: | August 2003 |
| Scale: | 1 : 12500 |




Key
- water races
- existing fences
- existing roads
- irrigated area per hydrant
- possible future races

mainline pipes
- 200mm PVC Class B
- 175mm PVC Class B
- 150mm PVC Class B
- 125mm PVC Class B
- 100mm PVC Class B
- 80mm PVC Class B
- 65mm PVC Class B
- 50mm PVC Class B
- 63mm OD low density poly pipe feed line
- 50mm OD low density poly pipe feed line
- hydrant
- water supply and pump
- pressure reducing valves

Lower Zone:
Pump duty 149 m3/hr (41.3 l/s) at 60m head
19 Ezi-rain sprinkler lines
9 with 5 sprinklers at 25m spacing per line
6 with 6 sprinklers at 25m spacing per line
4 with 3 sprinklers at 25m spacing per line
10 shifts per rotation
2.6ha irrigated for each of the 5 sprinkler lines
for 12 hour watering 38mm applied
Note pressure reduction may be required on some of the lines

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# Irrigation Design
# Ezi-rain lower section

## Lismore Farm
## Hawkdun Irrigation Scheme

Designer: Lincoln Environmental
Date: August 2003
Scale: 1 : 12500

The topography of the block results in pressure control being required at a number of hydrants. This can either be achieved at the relative hydrants or within the mainline pipes. Similarly, on the spray lines where there is significant topography, pressure control may be required on the individual sprinklers. As with all sprinkler systems, it is anticipated that on-site refinement of the design will be required to ensure that the water is applied evenly. As outlined in Table 8, there is a 13.2 m pressure difference between the lowest pressure hydrant (at the top of the block near SH 85) and the highest pressure hydrant (near the dam). Similarly, within the areas irrigated from a particular hydrant, there is up to a maximum of 8 m from the lowest point to the highest, although most blocks have been designed to limit this variation to less than 4 m. Additional work will be required to determine how best to cater for these pressure differences (i.e. mainline pressure control, hydrant pressure control, or pressure control at the sprinkler). If these pressure variations are not accounted for, it will result in differential watering both within each block and from hydrant to hydrant.

*Table 8: Hydrant pressure for Ezi rain design*

| Situation at the hydrant | Pressure (m) |
|---|---|
| Lowest pressure | 25.3 |
| Highest Pressure | 38.5 |
| Average pressure | 32.4 |

### 7.4.2 Water Supply Details

As previously described, water supply to Lismore is from the Hawkdun Irrigation Scheme. The proposed reservoir will increase the reliability of the water supply. A 250 mm diameter pipe will feed out of the dam and connect to the suction side of the pump.

### 7.4.3 Irrigation Operation and Management

As outlined above, the system will be run in two 12-hour sections each day. Shifting of 36 K Lines is expected to take less than 3 minutes each, or about 1½ hours per day. Operation is expected to be relatively straightforward, and can be set up on a timer so that the sections automatically switch over at a certain time each day. It is usual practice to shift all the lines close to the switch-over time (i.e. the non-operating lines are shifted immediately prior to the switch-over, and once the system has switched over, the sprinklers that have recently stopped are shifted). This means that the shifting can be scheduled for a single time each day. As with all irrigation systems, routine maintenance will be required (e.g. greasing the pump, cleaning filters etc.).

## 7.5 Plan 3 – Hybrid System (part K Line and part Roto-Rainer)

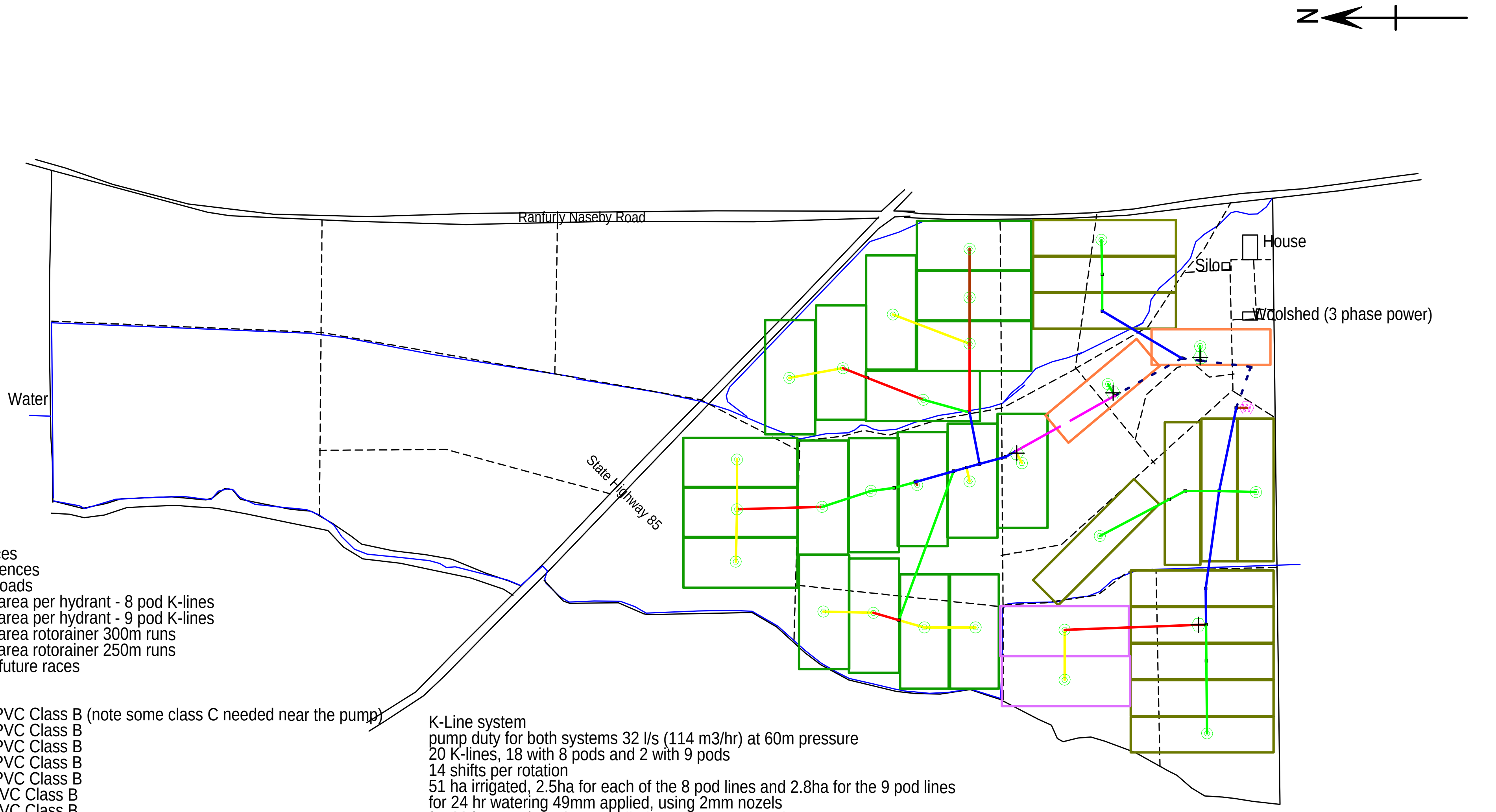
### 7.5.1 System Description

This system is based on the earlier K Line design, but attempts to use the higher pressures at the lower parts of the area by using a Roto-Rainer, which operates at a slightly higher pressure than the K Lines. The design is based on using the standard K Line system to irrigate the upper part of the area with a small Roto-Rainer used to irrigate the lower sections. The K Line section is based around using 8-pod K Lines, with 15 m shifts on a 14-day rotation. As such, each K Line will water 2.5 ha. The K Line length has been limited to 8 pods to reduce the differential pressure differences down each line. Where possible, the K Lines have been run parallel to the contour. To make shifting easier, each of the K Lines has been designed to fit within a rectangular 240 m by 105 m watered area. The Roto-Rainer section is based on using an irrigator similar to a Briggs 125 Roto-Rainer with 140 m of 80 mm hose. The system is based on fourteen 300 m runs, with one run per day. The system has been designed to work with existing shelter belts and the existing water supply race, although re-fencing will be required.

As outlined in Figure 18, the proposed plan consists of 20 K Lines, 18 of which have 8 pods, with the remaining two having 9 pods. A total of 51 ha are irrigated using K Line, with a further 31 ha irrigated using the Roto-Rainer. Assuming that the K Lines run continuously for 24 hours a day, 2 mm nozzles will apply 49 mm of water, which is slightly over the desired application depth of 45 mm (which represents 50% of the water-holding capacity of the Becks soil). It is anticipated that 2 mm nozzles will cause problems with blockage etc., especially as the water will be coming from the reservoir and is likely to contain algae etc. As such, it is recommended that at least 2.5 mm nozzles (or preferably 2.8 mm nozzles) be used. To prevent over-watering with the larger nozzles, the watering time will need to be reduced to 18-20 hours for the 2.5 mm nozzles and 16-18 hours for the 2.8 mm nozzles. Reducing the watering time provides plenty of time to shift the lines when they are empty, plus there is the ability to apply more water at the height of the season if required. Reducing the watering time will also fit in better with the need to shift the Roto-Rainer.

A pump that can supply 32 ℓ/s at 60 m pressure will be required. Once again, a Southern Cross 100×65-200 pump, with a 218 mm impeller attached to a 30 kW motor, will be appropriate.

The pipe network has been designed so that Class B PVC pipe can be used throughout. The design criterion has been to supply 28 m of pressure at the Roto-Rainer (includes losses in the drag hose), with the K Lines receiving 32 m of pressure at the hydrant. The topography and the need to keep maximum pressures under 60 m results in the pipes being designed to minimise friction losses. This causes many of the pipes to be larger than would normally be required for a low-pressure system. The maximum pipe velocities is only 1.4 m/s, with most velocities approximately 0.5 m/s. The pipe layout has been designed as a branching network to ensure that pipe diameters are minimised, although for the Roto-Rainer section – as all the water has to go to only one hydrant at a time – it requires larger diameter pipes.




Key
- water races
- existing fences
- existing roads
- irrigated area per hydrant - 8 pod K-lines
- irrigated area per hydrant - 9 pod K-lines
- irrigated area rotorainer 300m runs
- irrigated area rotorainer 250m runs
- possible future races

mainline pipes
- 200mm PVC Class B (note some class C needed near the pump)
- 175mm PVC Class B
- 150mm PVC Class B
- 125mm PVC Class B
- 100mm PVC Class B
- 80mm PVC Class B
- 65mm PVC Class B
- 50mm PVC Class B
- hydrant
- water supply and pump
- pressure reducing valves

K-Line system
pump duty for both systems 32 l/s (114 m3/hr) at 60m pressure
20 K-lines, 18 with 8 pods and 2 with 9 pods
14 shifts per rotation
51 ha irrigated, 2.5ha for each of the 8 pod lines and 2.8ha for the 9 pod lines
for 24 hr watering 49mm applied, using 2mm nozels
for 23 hr watering 46mm applied, wusing 2mm nozels

Rotorainer system
pump duty for both systems 32 l/s (114 m3/hr) at 60m pressure
14 runs, twelve 300m long and two 250m long all 75m wide
14 shifts per rotation
31 ha irrigated, 2.25ha per run
use a Briggs 125 Rotorainer or equalivant with 140m of Angus 80mm hose
for 23 hr watering 45mm applied

LINCOLN ENVIRONMENTAL
A division of Lincoln Ventures Ltd

# Irrigation Design
# K-Line and Roto-Rainer

# Lismore Farm
# Hawkdun Irrigation Scheme

| | |
|---|---|
| Designer: | Lincoln Environmental |
| Date: | August 2003 |
| Scale: | 1 : 12500 |

The topography of the block results in pressure control being required at a number of hydrants. This can either be achieved at the relative hydrants or within the mainline pipes. On the spray lines where there is significant topography, pressure control may be required on the individual sprinklers. As with all irrigation systems, it is anticipated that on-site refinement of the design will be required to ensure the water is applied evenly. As outlined in Table 9, there is a 12.9 m pressure difference between the lowest pressure hydrant (at the top of the block near SH 85) and the highest pressure hydrant (near the dam). Similarly, within the areas irrigated from a particular hydrant, there is up to a maximum of 8 m from the lowest point to the highest, although most blocks have been designed to limit this variation to less than 4 m. Additional work will be required to determine how best to cater for these pressure differences (i.e. mainline pressure control, hydrant pressure control, or pressure control at the sprinkler). It is noted that if these pressure variations are not accounted for, it will result in differential watering both within each block and from hydrant to hydrant.

*Table 9: Hydrant pressure for hybrid design*

| Situation at the hydrant | Pressure (m) |
|---|---|
| Lowest pressure | 26.0 |
| Highest Pressure | 38.9 |
| Average pressure | 32.1 |

### 7.5.2 Water Supply Details

As previously described, water supply to Lismore is from the Hawkdun Irrigation Scheme. The proposed reservoir will increase the reliability of the water supply. A 250 mm diameter pipe will feed out of the dam and connect to the suction side of the pump.

### 7.5.3 Irrigation Operation and Management

As outlined above, the K Line system will be run from between 16-24 hours a day, depending on the size of the nozzles used. Shifting of 20 K Lines is expected to take approximately 3 minutes each, or about 1 hour per day. The Roto-Rainer will operate for approximately 23 hours a day, and will take about 30 min to shift. Operation is expected to be relatively straightforward, although there will be some juggling between the two systems.

# 8 BILL OF MATERIALS AND APPROXIMATE COSTS

## 8.1 Bill of Materials and Capital Costs

Table 10 to Table 12 outlines the materials required for each of the options, and provides an estimated cost based on Lincoln Environmental's database. It is recommended that a detailed quotation be obtained from local suppliers to confirm the cost estimates. The three options have been priced on the same basis, and while the exact numerical value may not be correct, they allow comparison between the various options.

*Table 10: Estimated bill of materials and costs for the K Line option*

| Materials | Length or number | Unit cost ($) | Cost ($) |
|---|---:|---:|---:|
| ***Mainline pipe*** | | | |
| 200 mm Class B PVC | 30 | 21 | 630 |
| 175 mm Class B PVC | 140 | 17 | 2,380 |
| 150 mm Class B PVC | 450 | 12 | 5,400 |
| 125 mm Class B PVC | 1,140 | 9 | 10,260 |
| 100 mm Class B PVC | 1,326 | 7 | 9,282 |
| 80 mm Class B PVC | 1,680 | 5 | 8,400 |
| 65 mm Class B PVC | 546 | 3 | 1,638 |
| 50 mm Class B PVC | 100 | 2 | 200 |
| ***Irrigators*** | | | |
| 10-pod K Lines with riser | 21 | 1,200 | 25,200 |
| 8-pod K Lines with riser | 8 | 960 | 7,680 |
| ***Additional items*** | | | |
| Pipe fittings | 10% of pipe cost | 3,819 | 3,819 |
| Pipe laying (estimated $5/m) | 5,412 | 5 | 27,060 |
| Pressure control | Various | 2,000 | 2,000 |
| Southern Cross 100×65-200 pump with 218 mm impeller and 30 kW motor | 1 | 5,411 | 5,411 |
| Three-phase power supply (estimated) | 1 | 10,000 | 10,000 |
| **Total for 88 ha** | | | **119,360** |
| **Price per ha** | | | **1,356** |

*Table 11: Estimated bill of materials and costs for the Ezi rain option*

| Materials | Length or number | Unit cost ($) | Cost ($) |
|---|---|---|---|
| ***Mainline pipe*** | | | |
| 200 mm Class B PVC | 726 | 21 | 15,246 |
| 200 mm Class C PVC | 120 | 30 | 3,600 |
| 175 mm Class B PVC | 0 | 17 | 0 |
| 150 mm Class B PVC | 250 | 12 | 3,000 |
| 125 mm Class B PVC | 690 | 9 | 6,210 |
| 100 mm Class B PVC | 1,470 | 7 | 10,290 |
| 80 mm Class B PVC | 850 | 5 | 4,250 |
| 65 mm Class B PVC | 1,500 | 3 | 4,500 |
| 50 mm Class B PVC | 200 | 2 | 400 |
| ***Irrigators*** | | | |
| 6-sprinkler Ezi rain line with riser | 6 | 1,700 | 10,200 |
| 5-sprinkler Ezi rain line with riser | 26 | 1,550 | 40,300 |
| 3-sprinkler Ezi rain line with riser | 4 | 1,250 | 5,000 |
| 63 mm feed line | 2,100 | 3 | 6,300 |
| 50 mm feed line | 420 | 2 | 840 |
| ***Additional items*** | | | |
| Pipe fittings | 10% of pipe cost | 4,750 | 4,750 |
| Pipe laying (estimated $5/m) | 5,806 | 5 | 29,030 |
| Pressure control | Various | 2,000 | 2,000 |
| Southern Cross 100×65-200 pump with 218 mm impeller and 30 kW motor | 1 | 5,411 | 5,411 |
| Three phase power supply (estimated) | 1 | 10,000 | 10,000 |
| **Total for 95 ha** | | | **161,327** |
| **Price per ha** | | | **1,698** |

Discussions with Water Dynamics indicated that, on average, Ezi rain is $100 to $150 more per ha than traditional K Line systems. The prices above generally agree with this rule-of-thumb. Water Dynamics offers a free design service as part of any job. If Ezi rain is considered, then it is recommended that this option be taken up; particularly since Ezi rain is new on the market, and it is best to get the people who developed it to finalise any on-farm design.

*Table 12: Estimated bill of materials and costs for the K Line and Roto-Rainer option*

| Materials | Length or number | Unit cost ($) | Cost ($) |
|---|---|---|---|
| ***Mainline pipe*** | | | |
| 200mm Class B PVC | 30 | 21 | 630 |
| 200 mm Class C PVC | 0 | 30 | 0 |
| 175 mm Class B PVC | 400 | 17 | 6,800 |
| 150 mm Class B PVC | 240 | 12 | 2,880 |
| 125 mm Class B PVC | 990 | 9 | 8,910 |
| 100 mm Class B PVC | 1,430 | 7 | 10,010 |
| 80 mm Class B PVC | 860 | 5 | 4,300 |
| 65 mm Class B PVC | 940 | 3 | 2,820 |
| 50 mm Class B PVC | 210 | 2 | 420 |
| ***Irrigators*** | | | |
| 9-pod K Lines with riser | 2 | 1,080 | 2,160 |
| 8-pod K Lines with riser | 18 | 960 | 17,280 |
| Brigs 125 Roto-Rainer | 1 | 27,419 | 27,419 |
| 80 mm Angus hose | 140 | 31 | 4,340 |
| Hose trailer | 1 | 4,800 | 4,800 |
| Roto-Rainer hydrants | 14 | 445 | 6,230 |
| ***Additional items*** | | | |
| Pipe fittings | 10% of pipe cost | 3,677 | 3,677 |
| Pipe laying (estimated $5/m) | 5,100 | 5 | 25,500 |
| Pressure control | Various | 2,000 | 2,000 |
| Southern Cross 100×65-200 pump with 218 mm impeller and 30 kW motor | 1 | 5,411 | 5,411 |
| Three-phase power supply (estimated) | 1 | 10,000 | 10,000 |
| **Total for 82 ha** | | | **145,587** |
| **Price per ha** | | | **1,775** |

## 8.2 Operational Costs

Operation costs associated with irrigation generally fall under four categories: labour required to shift the irrigators, power costs associated with pumping, water supply costs (if any), and maintenance costs. Given that the three systems require similar pump duties shifting times and capital input, the operational costs for all three designs will be similar. It is estimated that operational costs will be in the order of $8,000 to $9,000 for electricity charges (based on a unit charge of $0.10/kWh, 2,500 operating hours per year, and a fixed charge of $16/kW of motor size – these costs were obtained from current power charges in Ida Valley). Approximately 1½ person hours will be required per day for shifting (10.5 hours a week or approximately 4½ weeks over a 120-day irrigation season). The maintenance costs will be in the order of $7,500 annually, although this is expected to be considerably less during the first few seasons, as the system will be new. The water supply charges will be the same for all three systems and will depend on the Hawkdun Irrigation Company charges.

# 9 SUMMARY AND FUTURE MANAGEMENT

A brief summary of the three options, and the advantages and disadvantages of each is given in the following table:

*Table 13: Summary of irrigation options*

| Option | Advantages | Disadvantages |
|---|---|---|
| Traditional K Line | • Grass growth responds well to K Lines<br>• Low capital cost<br>• Good introduction to irrigation<br>• Low application rates<br>• Low pressure system | • Labour intensive<br>• Potential for over-watering due to high application depths<br>• Long-term reliability somewhat unknown.<br>• Poor uniformity of watering<br>• Blockages of nozzles if the water is dirty<br>• Difficult to change system once established |
| Ezi rain | • As above but slighter higher capital cost and pressure<br>• Better uniformity of watering than traditional K Line<br>• Nozzles large enough not to block<br>• Slightly easier shifting than traditional K Line | • Labour intensive<br>• Potential for over-watering due to high application depths<br>• Long-term reliability somewhat unknown<br>• Difficult to change system once established |
| Hybrid – K Line & Roto-Rainer<br>(comments only relate to Roto-Rainer as K Line already discussed) | • Good uniformity of watering if no wind<br>• Proven technology<br>• Better use of the pressure in the system | • Higher capital cost for the pipes in the ground<br>• Labour intensive when shifting<br>• Is affected by wind<br>• Higher application rates<br>• Easier to change system once established |

Discussions with the Dowles indicated that they plan to use the proposed irrigation development as an intensive fattening and finishing block, to be run in association with their current sheep farming practices. As with any farm development, the objective is to maximise feed production and, therefore, return to the landowner. Production is related to many variables, including (but not limited to) grass species, fertiliser, water regime, grazing management, etc. If considerable effort is put into improving watering on Lismore, similar effort should also go into the other variables that contribute to maximising production.

# 10 CONCLUSIONS

The lack of reliability of water supply from the Hawkdun Irrigation Scheme severely limits both the existing irrigation on Lismore and any future development. To overcome this, any future irrigation development must be associated with the establishment of a storage reservoir to increase reliability of water supply. Given the cost associated with such a storage dam and the general lack of water in the Hawkdun Irrigation Scheme, it is essential that any water stored is used as efficiently and effectively as possible. As such, three potential irrigation development plans have been developed using low-pressure spray systems. The three systems are fairly similar, and are designed to provide a similar outcome in terms of production. The plans are in conceptual form to allow the merits of each design to be assessed. It is suggested that once a system has been selected, further detailed design should be undertaken to optimise the on-farm layout, and that a detailed quote be obtained for the final design.

# 11 REFERENCES

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Cossens, G.G. and Rickard, D.S.(1968): Irrigation Investigations in Otago, New Zealand - V - Physical properties of soils of the Maniototo Plains. New Zealand Journal of Agricultural Research (1969) Vol. 12, Pg 193-213

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# APPENDIX 1:

# Storage reservoir report

**(Refer to: 4590Hawkdun+Lismore_rpt1)**