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Spray Irrigation in the Lower Waitaki Irrigation Scheme

Water Allocation Guidelines

Prepared for Lower Waitaki Irrigation Company

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Prepared by:	Andrew Dark		
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www.aqualinc.com

CHRISTCHURCH PO Box 20426, Bishopdale, Christchurch, New Zealand. Phone +64 3 964 6512. Fax +64 3 9646520.

HAMILTON PO Box 14-041, Enderley, Hamilton, New Zealand. Phone +64 7 858 4851. Fax +64 7 858 4847.

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EXECUTIVE SUMMARY

Guidelines for daily allocation rates for spray irrigation in the Lower Waitaki Valley are given according to soil type. The recommended rates are based on the results of a study on irrigation requirements for North Otago, completed by Lincoln Environmental in 2003. The values given have been generalised for crops and pasture, and for different spray irrigation systems.

Table 1: Recommended allocation guidelines for the LWIS

Soil Series	Soil Type	Daily Allocation (ℓ/s/ha)	Daily Allocation (mm/day)
Light	Shallow very stony sand and very stony sandy/silt loam (Waimakariri, Eyre, Paparua, Steward etc)	0.55	4.8
Medium	Shallow-medium silt loam/sandy loam, few stones (Waimakariri, Steward, Eyre, Pukeuri etc)	0.50	4.3
Heavy	Deep silt and clay loams (Taitapu etc)	0.45	3.9

A map displaying the soil types is included in Appendix A.

1 INTRODUCTION

A number of shareholders in the Lower Waitaki Irrigation Scheme (LWIS) are converting from border strip irrigation to spray irrigation. The purpose of this report is to recommend guidelines for daily allocation rates for spray irrigation in the Lower Waitaki Irrigation Scheme.

2 MAJOR SOIL TYPES IN THE LOWER WAITAKI IRRIGATION SCHEME

Information on soil types and soil properties in the LWIS area was taken from Landcare Research's Land Resource Information System (LRIS).

2.1 Spatial Distribution of Soil Types in Scheme

The soils of the LWIS can be divided into three zones:

- downlands margin;
- fans and high terraces; and
- lower terraces and floodplain.

A map of the spatial distribution of soil series in the scheme area is shown in Appendix A.

The soils of the downlands margin are primarily Pukeuri silt loams and shallow silt loams.

The fans and high terraces contain Steward soils, which range from stony sandy loams to very stony silt loams. The Steward soils are, in some locations, known to have impervious pans at variable and often shallow depths (LWIC, 1998).

The soils of the lower terraces and floodplain are mainly Paparua and Waimakariri soils, which are stony to very stony sands and sandy loams, with some Eyre shallow silt loam and Taitapu complex.

2.2 Profile Available Water (PAW) for Major Soil Types

The soil property that most influences irrigation requirements is the profile available water (PAW). This is the depth of water in the soil column that is available to plants when the soil is at field capacity. PAW is determined by the soil water holding capacity and the root depth of the crop.

Median PAW values for the major soil types in the scheme were determined from the LRIS. These values were given for a 900 mm rooting depth, and it was necessary to convert them to 600 mm rooting depth, which is assumed to be the standard rooting depth for pasture. It was assumed that the top 200 mm of soil contributes 40 mm of water, and the remainder of the soil profile contributes a constant amount of water per unit depth. This methodology is consistent with Lincoln Environmental Report No 4661/1 on irrigation requirements for North Otago (LE [2003]). PAW values for a 600 mm rooting depth are shown in Table 2.

Table 2: PAW values for soils in the LWIS area

Soil Series	Soil Type	PAW (mm) for 600 mm root depth
Waimakariri	very stony sand and very stony sandy loam	51
Paparua	very stony sandy loam and very stony silt loam	60
Waimakariri	stony sandy loam	60
Pukeuri	silt loam	60
Steward	very stony silt loam	60
Paparua	stony sandy loam	77
Eyre	shallow silt loam	77
Paparua	stony sandy loam	77
Steward	stony sandy loam	77
Pukeuri	shallow silt loam	86
Taitapu	complex	160

There is a general trend of decreasing PAW values moving from the downlands margin towards the Waitaki River. However, there is variation within each soil series, and it is therefore not possible to assign general PAW values to each of the three zones of the scheme. A map of the distribution of PAW values over the scheme area is shown in Appendix B.

Pan formation in the Steward soils may restrict the rooting depth and reduce the PAW values below the values given in Table 2 for these soils.

The Taitapu complex soil, which has a PAW that is much higher than any other soils in the scheme, is confined to a relatively small area of the lower terraces and floodplain.

3 RECOMMENDATIONS FROM PREVIOUS WORK

A detailed investigation of irrigation requirements for North Otago was carried out by Lincoln Environmental in 2003. This study used a soil water balance model to simulate irrigation demand over twenty-five years of climate data for intensive pasture and a range of crops. An iteration process was used to recommend optimum irrigation strategies based on the simulation results for a range of PAW values.

3.1 Methodology and Assumptions

The Lincoln Environmental study assumed that 50% of the PAW was applied when the soil moisture level was below 50% of the PAW at the start of an irrigation cycle.

In recognition of the fact that it is not realistic or economic to meet the maximum demand for water 100% of the time, the acceptable risk of not meeting the full demand was set at 10%. The irrigation objective was therefore to maintain soil moisture levels above 50% of PAW for 90% of the time. Soil moisture was never allowed to drop below 25% of PAW. The irrigation strategy was adjusted iteratively and optimised to give the longest return period that would meet the irrigation objective.

Irrigation application efficiency, which is defined as the volume of water stored in the crop root zone divided by the volume of water applied, was set at 85%. This value was considered to be reasonable for a well-managed sprinkler system.

It was assumed that water was available on demand whenever needed. The study did not, therefore, account for situations where it is necessary to “catch-up” after water supply restrictions.

For each soil type used in the modelling, it was assumed that the minimum return period was fixed throughout the season.

3.2 Climate Data

The climate data used in the irrigation demand simulations was taken from NIWA rainfall and climate sites in North Otago. Daily rainfall data was taken from Oamaru Airport. Potential Evapotranspiration (PET) data was taken from Windsor Climate Station.

3.3 Results

Daily allocation requirements for North Otago soils are shown in Table 3 for the range of PAW values present in the LWIS area.

Table 3: Reasonable and efficient irrigation requirements for North Otago (LE, 2003)

Soil PAW (mm) for 600 mm root depth	Application Depth (mm)	Return Interval (days)	Daily Allocation (ℓ/s/ha)
40	20	5	0.45
60	30	8	0.43
80	40	11	0.41
100	50	15	0.39
160	80	26	0.35

4 DISCUSSION

4.1 Assumptions in LE Report

The 85% application efficiency assumed in LE (2003) is too high for K-lines and similar systems and is at the upper end of the achievable range for travelling gun and centre-pivot systems. However, if the actual efficiency of a system is known, the values given in Table 3 can be adjusted using the ratio of the assumed and actual efficiencies.

The other assumptions and general methodology used in LE (2003) are considered appropriate for the LWIS area.

4.2 Climate Data

The Oamaru Airport rainfall data is the most relevant available data for the LWIS area.

The applicability of the Windsor ET data could be questioned due to the higher elevation of the climate station and the sheltering effect of the hills in this area. PET values in the scheme area may be slightly elevated above the Windsor values due to greater exposure to sea-breezes. The other factors that influence PET - temperature, humidity, pressure and solar radiation - are likely to be very similar between Windsor climate station and the Lower Waitaki Valley area. Maps of spatial climatic variations included in LE (2003) show that the difference in PET between Windsor and the LWIS area is likely to be less than 5%.

4.3 Effect of Variations in Crops

The recommended allocations shown in Table 3 were calculated for pasture. To allow for the differences in evapotranspiration between crops and pasture, a crop-coefficient can be applied to the rates allocated for pasture. Although the crop-coefficient will vary throughout the season, an estimate of the peak daily demand for crops can be made by assuming that the mid-season value of the crop-coefficient coincides with the period of highest PET.

For crops that are likely to be grown in the Lower Waitaki Valley, such as potatoes, wheat and barley, Allen et al. (1998) give a mid-season crop-coefficient of 1.15. This means that the peak daily demand for crop irrigation is likely to be 15% greater than for pasture.

5 RECOMMENDATIONS FOR THE LWIS

5.1 Calculated Allocation Guidelines

To allow for variations in irrigation systems in the Lower Waitaki Scheme area, an application efficiency of 80%, rather than 85%, has been adopted.

A crop coefficient of 1.15 has been applied, so that the recommended values can be considered to be generalised for crops and pasture.

The following table gives recommended allocation rates based on the major soil types in the LWIS area, based on the recommended daily allocation rates in LE (2003). Where soil PAW values fall approximately half-way between the values given in Table 3, the allocation rates have been rounded to the rate for the lower PAW value, as this given the most conservative allocation rate.

Table 4: Calculated allocation guidelines for the LWIS

Soil Series	Soil Type	Daily Allocation (ℓ/s/ha)	Daily Allocation (mm/day)
Paparua	very stony sandy loam and very stony silt loam	0.53	4.6
Paparua	stony sandy loam	0.53	4.6
Steward	very stony silt loam	0.53	4.6
Steward	stony sandy loam	0.50	4.3
Eyre	shallow silt loam	0.50	4.3
Pukeuri	silt loam	0.53	4.6
Pukeuri	shallow silt loam	0.50	4.3
Waimakariri	very stony sand and very stony sandy loam	0.55	4.8
Waimakariri	stony sandy loam	0.53	4.6
Taitapu	Complex	0.43	3.7

5.2 Practical Allocation Guidelines

Because of the number of different soil types and plant available water values in the Lower Waitaki Irrigation Scheme area, it is unrealistic to precisely determine plant available water values for each property.

In addition, some allowance needs to be made for systems to "catch up" after restrictions due to scheme operation or other reasons.

To simplify the allocation system, it would be prudent to reduce the number of bands to a maximum of three. The following is suggested:

Table 5: Recommended allocation guidelines for the LWIS

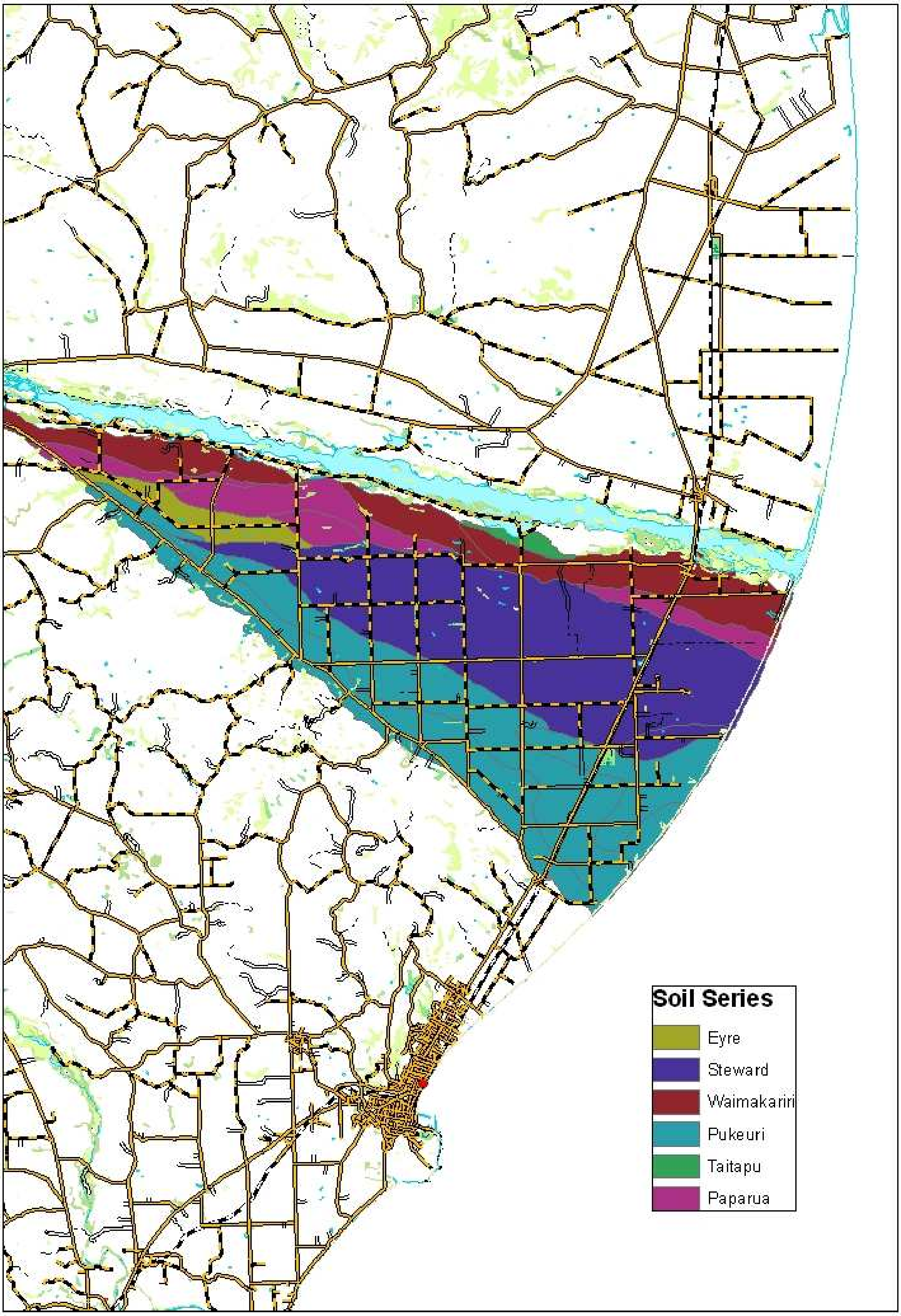
Soil Series	**Soil Type**	**Daily Allocation (ℓ/s/ha)**	**Daily Allocation (mm/day)**
Light	Shallow very stony sand and very stony sandy/silt loam (Waimakariri, Eyre, Paparua, Steward etc)	0.55	4.8
Medium	Shallow-medium silt loam/sandy loam, few stones (Waimakariri, Steward, Eyre, Pukeuri etc)	0.50	4.3
Heavy	Deep silt and clay loams (Taitapu etc)	0.45	3.9

6 REFERENCES

Allen, R.G; Pereira L.S; Raes, D and Smith, S (1998): Crop Evapotranspiration. *FAO Irrigation and Drainage Paper No 56.*

LE (2003): Irrigation Requirements for North Otago. Report No 4661/1, prepared for Otago Regional Council.

Appendix A: Map of soil series in the LWIS area



Appendix B: Map of PAW values in the LWIS area