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Irrigation Efficiency in Rangitikei District

Report prepared as part of the

Rangitikei Strategic Water Assessment project,

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Rangitikei
Unspoilt...

Ministry for Primary Industries
Manatū Ahu Matua

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1 Introduction

The Rangitikei district is heavily reliant upon the primary sector for its economic and social well-being. This sector is founded upon the district's topography, soils, climate, water resources, and farmer innovation. However, the district's water resource is coming under increasing pressure from irrigators, and the impacts of droughts.

In response to these challenges the Rangitikei District Council and Ministry for Primary Industries (via the Irrigation Acceleration Fund) are jointly funding The Catalyst Group to undertake a strategic water assessment for the district. This project will generate information about the:

- availability and certainty of water supply (surface and groundwater) in the district;
- efficiency of current water use, and opportunities for improvement;
- costs, benefits, on-farm implications, and regulatory and environmental considerations around irrigation, and
- alternative uses for irrigated land.

Such an assessment is a priority for Rangitikei District Council as this project will provide guidance on what additional benefits and opportunities could arise through smart use of the water resource, and identification of the costs of capitalising on these opportunities at a district and individual level.

One of the tasks within the wider Rangitikei Strategic Water Assessment project is an assessment of whether water is being used efficiently for irrigation purposes by landowners in the Rangitikei district, and what tools landowners have adopted to achieve efficient water use. Water use efficiency can be assessed using a multitude of measures. For this report the authors focussed on the efficiency of water distribution and application. Measures of efficiency of conversion of applied water into dry matter produced, or profitability on water applied, are not considered as part of this report, but are touched upon within the case study assessments produced as part of the wider Rangitikei Strategic Water Assessment project.

The purpose of this review was to:

- ascertain landowner attitude to efficient water use and barriers to adoption of irrigation management tools,
- determine what tools landowners have adopted to improve water use efficiency,
- identify what tools are available to improve water use efficiency, and their respective costs and benefits, and
- discuss the on-farm and district-wide implications of any findings.

2 Background

Irrigation can generate many benefits for landowners and the wider economy. However, as the area under irrigation increases and the water resources being tapped to supply this irrigation are nearing their allocation limits, irrigation efficiency becomes a critical issue. Landowners are coming under pressure to demonstrate they are using the finite water resource effectively, efficiently and sustainably.

There are many potential environmental and economic benefits to improving irrigation efficiency, including:

- less stress on water resources;
- reduced losses of water and nutrients to groundwater and surface waters;
- minimising irrigation inputs while continuing to maintain/improve production and overall profits, and
- allowing a greater area to be irrigated with a given volume of water.

The literature abounds with definitions of irrigation efficiency. However, the measures of interest to this review are application and distribution efficiency. Application efficiency (AE) is a measure of the percentage of water delivered to the paddock that can be used by the crop (grass, grain, or vegetable) being irrigated. High application efficiency produces high crop yields with low volumes of irrigation. Distribution efficiency (DE) is a measure of distribution uniformity and has a significant effect on application efficiency. High application efficiency means a high proportion of the water applied is used by the crop, whereas low application efficiency means much of the water is lost to runoff or drainage.

Optimising crop water use efficiency requires a landowner to know when to start irrigating, when to stop, how much water should be applied, and when the water should be applied and where. Such decisions are influenced by considerations of rainfall, soil depth, soil moisture, soil temperature, crop type and stage, irrigator type, and water availability. During the last few years the number of tools available to landowners to balance these considerations, support irrigation management and decision-making, and improve water use efficiency has increased markedly. Ultimately though, the level of irrigation efficiency achieved on-farm depends upon landowner attitude towards the adoption and utilisation of such tools.

Research into irrigation efficiency within New Zealand has revealed significant variations across landowners and farming enterprises (Aqualinc, 2006), which is consistent with results from overseas. Previous research identifies the key factors influencing irrigation efficiency as:

- how well the system is designed, and
- how well the system is managed.

Despite the obvious benefits of more efficient irrigation systems, designing and running a system that is 100% efficient, although technically possible, is unlikely to be viable. This is because any system needs to strike a balance between efficiency and other interacting factors such as capital cost, operational costs and labour.

3 Method

An interview approach was used to generate information on irrigation generally and irrigation efficiency in particular within the Rangitikei district. Two local irrigation experts were interviewed as part of this report:

- Stu Bradbury - chief executive of Precision Irrigation in Manawatu. Precision Irrigation is a nationwide consultancy service that provides advice and designs/supplies products to improve the efficiency and profitability of existing and new irrigation systems. Precision Irrigation deals with a small number of clients in the Manawatu-Whanganui region
- Ben Carswell – field advisor for WaterForce Manawatu. WaterForce is a nationwide company specialising in the design, installation and servicing of water pumping, distribution and irrigation infrastructure. WaterForce deals with approximately 90% of irrigators in the Manawatu-Whanganui region.

The interviews were conducted informally, but structured around a pre-circulated series of questions (Annex A). Each interview lasted approximately 1.5 hours, with interviews conducted by Alistair Beveridge of The Catalyst Group.

As the interviews progressed, both interviewees became more comfortable, and each question was answered more freely. Both interviewees gave freely of their experiences and knowledge, and there was a good flow of information between interviewer and interviewee.

Responses generated during these interviews were supplemented by information collected during the case study component of the wider Rangitikei Strategic Water Assessment. This component involves the development of up to 10 detailed analyses of irrigated and non-irrigated farms. The purpose of which is to investigate the costs and benefits of irrigation, changes to farming systems as a consequence of irrigation, and nutrient management implications at the property scale. Case study information was used to field check the information generated during the interview process.

Given an interview-based approach was used to inform this report, the results and conclusions presented below are necessarily qualitative and generalised in nature.

4 Results

4.1 Irrigation efficiency as a priority

The consensus was that most landowners in the local area do not consider water use or irrigation efficiency a priority. Notable exceptions to this include the Darylmple's who are recognised nationally as an example of best practice around irrigation efficiency.

The key reasons suggested for the low priority placed on irrigation efficiency were that there is still plenty of water and the cost of accessing water is low. This contrasts with experience from Canterbury where efficiency is a much greater consideration due to the restrictions on water availability, and the costs of securing the water (both shares and unit charges) from water supply schemes.

At this stage the One Plan provisions relating to water use and irrigation efficiency (Annex B) are not thought to be driving behaviour change. This is because the One Plan provisions only have relevance when applying for a new water take consent or seeking renewal of an existing consent. Most irrigators in the Rangitikei district have several years left to run on their existing consents. Further, the One Plan provisions are not considered to be particularly onerous, as they essentially reinforce current best practice. Interestingly, both interviewees thought the One Plan provisions relating to nutrient loss limits were likely to be a greater driver of irrigation efficiency than the water use/irrigation provisions.

The interviewees made a number of further observations regarding the adoption of efficiency technologies:

- infrastructure age – much of the irrigation infrastructure in the Rangitikei district is >15 years old, so there are inherent limitations around what efficiency improvements are possible. Significant potential exists for lifting irrigation efficiency in the district as current infrastructure is replaced by more modern equipment.
- the irrigation journey of discovery – both interviewee's related that most landowners follow a well-trodden personal journey of discovery in relation to irrigation. Initially, landowners are interested in getting their systems set up and running, with a focus on 'getting water on the ground'. However, as time passes, landowners become more aware of the costs of running their irrigation systems, and so begin tweaking their systems in an attempt to reduce costs. The final step in the journey is about optimising water and land use to maximise productivity. Depending upon the farmer, this journey can take years through to decades.
- insurance versus investment – 'irrigation should be viewed as an investment not an insurance policy'. That is, rather that viewing irrigation simply as a means of surviving dry summers, the introduction of irrigation should be the catalyst for changing what and how land is being used in an attempt to maximise production and profitability. 'Irrigation is a game changer'. Sheep and beef farmers typically fall into the trap of treating irrigation as insurance, and have proven resistant to taking the next steps to capitalise on their investment.
- finance – the availability of finance is not a barrier to the uptake of irrigation efficiency tools and systems, with banks willing to offer finance on the basis of the projected pay-back period (refer Section 4.3 below)
- irrigator type – in most situations and under most conditions, a pivot irrigator is more efficient than alternative irrigator types e.g. K-line.
- water supply – a reliable water supply is critical to achieving high irrigation allows, as this ensures water use can be matched to need rather than availability, and owners to maximise the benefits of rainfall. An unreliable water supply can lead to cycles of over-application and drying out.

4.2 Irrigation efficiency technologies

The interviewees agreed the level of irrigation efficiency achievable on-farm is influenced by a number of factors. Of critical importance were decisions made during initial set-up – bore depth, location and diameter; water storage volume and location; water distribution network design; and irrigator type. Such decisions influence ongoing operating, maintenance and labour costs. Typically a higher initial capital investment will be returned through improved management and performance of the system long-term.

Beyond the initial system set-up, the interviewees suggested efficiency is driven by the adoption of technologies that allow greater matching of water application with on-farm soil/crop needs.

The technologies currently available to do this include:

- property soil map – to delineate the soils of the property on the basis of their water-holding capacity. Soils with different water-holding capacities need to be irrigated differently to prevent them becoming waterlogged or drying out
- soil moisture probes – devices that measure soil moisture levels to inform decisions around when to start irrigating, when to stop, and how much water to apply (when combined with the soil map information). The goal being to maintain soil moisture within optimal levels for the crop being grown.
- pumping and distribution – flow meters to calculate actual water supply, and variable speed pumps to allow variable irrigation application rates (and reduce wear and tear during pump start-up/stop).
- telemetry – the ability for devices like flow meters and soil moisture probes to send data to a centralised point such as a farmer's computer or mobile device.
- Variable Rate Irrigation (VRI) – the ability to programme a pivot irrigator (not available on other irrigation platforms) to vary the rate of irrigation by speeding up/slowing down the irrigator and/or by varying the volume of water applied so that the application rate matches the soil type and desired soil moisture levels, and to avoid water application to certain areas e.g. troughs and races. This set-up can be adapted to apply fertiliser and other agrichemicals.

The interviewees were quick to point out that not all of these technologies are suited to all farming types and situations. For example, a dairy farmer would likely benefit from adopting all of the above technologies. In contrast, a sheep/beef farmer irrigating a relatively small area of forage crop would realistically only benefit from a soil map and soil moisture probes.

4.3 Costs

Irrigation efficiency technology is not cheap, but the payback period is relatively quick, as demonstrated by the following example using a typical Manawatu-Whanganui region irrigation set-up:

- Initial set-up cost - $300-400k for a 7 span, 450m long pivot irrigator, with a basic pump and pipe work set-up. This does not include any costs associated with bore development, intake gallery, power supply, water storage or earthworks.
- Soil map – $3-5k for the entire farm
- Soil moisture – $15k for three probes to cover the entire farm
- Variable rate pump – $15k
- Variable rate irrigation - $55k

Based on the above figures the integration of efficiency technologies would cost approximately $90k, or between 23-30% of the initial set-up cost, if adopted during irrigator installation. Retrofitting these technologies to an existing irrigation system is estimated to cost a further $10-15k.

While these costs are high in real terms and relative to the set-up costs of a basic irrigator, both interviewees agreed that water savings of between 20-30% are achievable for the Rangitikei district from the adoption of efficiency technologies. When these water savings are translated into operating cost savings (power, maintenance, water scheme costs etc.), and combined with the potential productivity gains from improved irrigation management (e.g. increased crop yields), the payback period for the additional investment can be quite short. Examples were cited (admittedly not from the Manawatu-Whanganui region) of a payback period of just one year! A 3-4 year payback period is considered more realistic for this region.

4.4 Benefits

A range of benefits from improved irrigation efficiency, additional to increased productivity and profitability, were identified by interviewee's, including:

- Better land utilisation – matching irrigation rates to soil water holding capacity reduces the risk of overwatering. Such an approach has allowed landowners to bring areas of the property that were traditionally over wet and prone to pugging under their previous irrigation regime, into production, thereby increasing the effective area of the property.
- Plant health – matching irrigation rates to soil water holding capacity and plant growth needs reduces plant stress. Avoidance of repeated overwatering and drying-out cycles greatly reduces plant stress, and allows soil moisture levels to be maintained at or near optimal levels for plant health and growth.
- Nutrient management – matching irrigation rates to soil water holding capacity and plant growth needs reduces nutrient losses. Wet soils leak nutrients at a much greater rate than drier soils. Similarly, plants operating at optimal growth rates are more efficient at nutrient uptake than those with sub-optimal growth rates. Significant potential exists to reduce nutrient loss rates through the adoption of irrigation efficiency technologies. Unfortunately, Overseer (the industry-accepted nutrient assessment and management tool) requires further upgrading to better account for irrigation efficiency technology impacts on nutrient management/losses.
- Seed germination – irrigation can be used to manage the timing of seed germination across a property or paddock to ensure a continued supply of produce throughout the growing season. This is achieved by simply starting and stopping irrigation at different points across the property/paddock effectively using the provision/denial of water to moderate timing of seed germination.
- Crop variability – the ability to start and stop irrigation across a property, and/or vary the water application rate opens up possibilities of introducing new crops onto a property, be it crops into a predominantly pasture-based farm system, or a range of new crop types into an existing cropping farm.
- Irrigable area – with potential water savings of 20-30%, the adoption of irrigation efficiency technologies has significant implications for future irrigation and water availability within Rangitikei district. For example, the area currently under irrigation could be irrigated with 20-30% less water (freeing up water for others), or an additional 20-30% of land could be irrigated for the same amount of water (with a commensurate lift in production).

Although this is a qualitative rather than a quantitative assessment of irrigation efficiency technologies and their adoption within the Rangitikei district, this study still highlights a number of significant trends and conclusions.

Most notable of these is that the priority currently placed on irrigation efficiency by landowners is low. This situation is expected to change in coming years as landowners must make adjustments to meet One Plan requirements (relating to water use efficiency and nutrient management limits), and as existing irrigation infrastructure is replaced.

The productivity and profitability improvements possible from the introduction of irrigation are well documented, but a further significant step-up in farm profit, production and management improvements are possible through the adoption of irrigation efficiency technologies. Such technologies come at a cost (up to an additional 30% of the initial irrigation system set-up cost), but the payback period of 3-4 years makes such an investment financially sound.

Irrigation efficiency technologies can reduce irrigation water use by 20-30% on a per farm basis, with savings increasing with water supply security. When such savings are extrapolated across an entire district, a number of exciting possibilities open up, including:

- Increased water supply security to existing users (if no additional land is brought into irrigation)
- Increased area of irrigated land, without a corresponding increase in the current water use footprint
- More efficient utilisation, by a greater number of landowners across a greater area, of the remaining unallocated surface and groundwater resource than would otherwise be the case
- Improved instream water quality through reduced farm nutrient losses.

Another possibility to emerge from the adoption of irrigation efficiency technologies is the ability to undertake multiple land uses (i.e. pasture and cropping, range of crop types) on a single property.

In combination, these possibilities have the potential to significantly lift on-farm productivity and profitability through diversity and reduction of risk (e.g. fluctuations in the exchange rate and international commodity prices). This in turn has the potential to lift the economic performance and prosperity of the district as a whole.

5 Summary

The key findings from this assessment into the availability and adoption of irrigation efficiency technologies within the Rangitikei catchment are:

- There has been a low uptake of irrigation efficiency technologies in the Rangitikei district, and adopting these technologies is not currently seen as a priority by most landowners
- Adoption of such technologies is likely to speed up in the future as water take consents are renewed (to meet One Plan requirements for water use efficiency and nutrient loss targets), as existing irrigation infrastructure is replaced, as landowner knowledge increases, and as landowners begin viewing irrigation as an investment rather than just insurance.
- Irrigation efficiency technologies (soil maps, soil moisture probes, flow meters and telemetry, and variable rate irrigation), can cost up to an additional 30% over and above the initial costs of a basic irrigation set-up. Retrofitting of irrigation efficiency technologies to an existing irrigation set-up is slightly more expensive than installing them during initial set-up.
- Despite the relatively high cost of irrigation efficiency technologies, there is an expected payback period of 3-4 years, with banks willing to offer finance on the basis of this short payback period.
- Adoption of irrigation efficiency technologies can produce irrigation water use savings of 20-30%. The more secure the water supply the greater the water use saving.
- Irrigation efficiency technologies can improve on-farm profitability (by reducing costs and wastage), productivity (by optimizing crop type and growth, and land utilisation), management (e.g. timing of seed germination), and nutrient management (reduces losses).
- The adoption of irrigation efficiency technologies could free-up significant quantities of water for other users, and/or allow a much greater area of land to be irrigated within the Rangitikei district.
- Irrigation efficiency technologies have the potential to significantly lift the economic performance of individual farms and the wider Rangitikei district whilst ensuring sustainable use of the land and water resources.

6 References

Aqualinc (2006) Irrigation Efficiency Gaps – review and stock take. Report prepared for Sustainable Farming Fund and Irrigation New Zealand. Report No L05264/2

Annex A: Interview questions

The following questions were pre-circulated to the local irrigation experts interviewed as part of this assessment.

1. How much of a priority is irrigation efficiency for:
   - farmers in general?
   - farmers in the Rangitikei district?

2. Please explain your responses to Question 2 above.

3. What do you think are the underlying drivers for, or barriers to, adoption of irrigation efficiency systems and tools?

4. What tools/systems are farmers currently using to determine when, where, and how much they irrigate:
   - generally speaking?
   - in the Rangitikei district?

5. What tools/systems are available to improve water use efficiency?

6. What farm types/systems are these products best suited to?

7. What farm types/systems are not suited to the use of these products?

8. What are the typical costs of these products (using a measure like $/ha) when:
   - installed new?
   - retrofitted?

9. How do these additional costs compare with the initial set-up costs of installing irrigation?

10. What sorts of savings are possible using these products, in terms of:
    - water use?
    - costs?

11. What is the pay-back period on these products?

12. What other benefits/costs are associated with these products e.g. crop yield, labour costs, fertiliser application, soil health etc.?

13. Thinking about the Rangitikei district, what would be the key benefits of increased irrigation efficiency for:
    - farmers?
    - the district?
    - the environment?

Annex B: One Plan irrigation efficiency provisions

The following sets out the One Plan policies in relation to irrigation efficiency:

Policy 6-12: Reasonable and justifiable need for *water*

Subject to Policy 6-19, the amount of *water*^ taken by resource users must be reasonable and justifiable for the intended use. In addition, the following specific measures for ensuring reasonable and justifiable use of *water*^ must be taken into account when considering consent applications to take *water*^ for irrigation, ..., and during reviews of consent *conditions*^ for these activities.

(a) For irrigation, *resource consent*^ applications must be required to meet a reasonable use test in relation to the maximum daily rate of abstraction, the irrigation return period and the seasonal or annual volume of the proposed take. When making decisions on the reasonableness of the rate and volume of take sought, the Regional Council must:

(i) consider *land*^ use, crop *water*^ use requirements, on-site physical factors such as soil *water*^ holding capacity, and climatic factors such as rainfall variability and potential evapo-transpiration

(ii) assess applications either on the basis of an irrigation application efficiency of 80% (even if the actual system being used has a lower application efficiency), or on the basis of a higher efficiency where an application is for an irrigation system with a higher efficiency

(iii) link actual irrigation use to soil moisture measurements or daily soil moisture budgets in consent *conditions*^.

Policy 6-13: Efficient use of *water*^

Water^ must be used efficiently, including by the following measures:

(a) requiring *water*^ audits and *water*^ budgets to check for leakages and *water*^-use efficiency as appropriate

(b) requiring the use of, or progressive *upgrade** to, *infrastructure*^ for *water*^ distribution that minimises the loss of *water*^ and restricts the use of *water*^ to the amounts determined in accordance with Policy 6-12

...

(e) requiring monitoring of *water*^ takes, including by installing *water*^ metering and telemetry.