Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

IRRIGATION NEW ZEALAND

ECan Summer Student Irrigation Efficiency Pilot Program 2016–17

Contents

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Project partners

Executive summary

Irrigation efficiency has many definitions, it is a term often spoken but seldom understood. The most meaningful definition, from a practical view point, comes from an Aqualinc Research report – What is Irrigation Efficiency? – commissioned in 2012.The report states that irrigation efficiency can be best described as *"the % of the total irrigation volume applied to the soil that is retained in the root zone".* IrrigationNZ Code of Practice for Irrigation System Design – 2015, quantifies this percentage as *"a minimum of 80% of the applied depth should be retained in the rootzone"*. But there are several limiting characteristics that must be considered when interpreting whether any one irrigation system is delivering efficient irrigation.

The single most influential factor is the soil. Best described as "a plants fuel tank", soil water holding characteristics are a critical component in efficient irrigation. Farmer knowledge in this area is growing in both the concept of basic soil science and by practical application of on-farm strategies.

The second critical consideration is the irrigation system and the technologies deployed on-farm. Individual irrigation systems types all have unique characteristics that must be considered alongside operational management and maintenance. Some more modern irrigation systems deploy advanced information and sensor based technologies that advise the farmer on timing and depth of irrigation. The success of these technology based systems is often out of the farmers control and they rely heavily on a service support company to ensure the system is operating correctly.

Environment Canterbury (ECan), together with industry support from IrrigationNZ, DairyNZ, Beef & Lamb NZ, Foundation for Arable Research (FAR), Fonterra, Synlait, RDRML and Irrigo Centre Ltd, developed the concept of a pilot summer student project that would focus on irrigation efficiency on-farm within a single Canterbury zone. The students would be trained in basic level irrigation evaluation techniques by IrrigationNZ, and with help from wider industry support, would test up to 150 farms (300 irrigation systems) within the Ashburton zone. The results would be socialised with the participating farmers to increase their knowledge of the on-farm irrigation performance and allow one-on-one discussion around next steps.

The pilot project ran from the 1st November 2016 until the 28th March 2017, with the two selected students completing basic performance evaluations on 131 farms (244 systems). The participating farmers were asked a series of questions which focused on the irrigation system operation and maintenance as well as the technology systems employed on-farm, and any barriers to change the farmers experienced.

The pilot project found 73% of participating farms were primarily irrigated by highly efficient centre pivot and linear irrigators and that around 80% of participating farmers deployed either an information or sensor based decision support tool. There was some caution in adopting new and emerging technologies based on the risk of the technology failing and the level of after sales support currently offered.

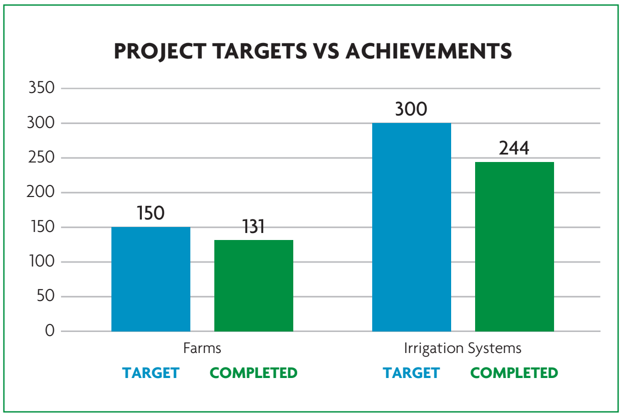
Participating farmers indicated that they are accepting of the new expectations around the use of water for irrigation but were conscious of the risk of shifting expectations to a national level. Investment in irrigation infrastructure comes at a significant cost and any shift in regulatory requirements could mean additional investment.

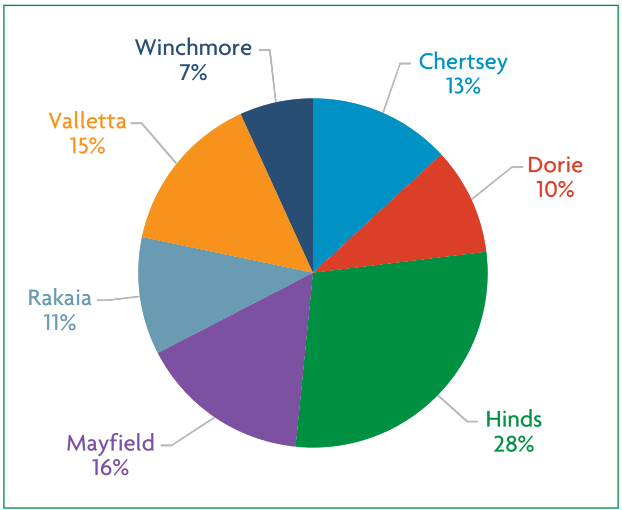
A key opportunity highlighted by the pilot project, was the need for better understanding between the service companies delivering the infrastructure and technologies, and the regulatory environment. Many of the system tested had underlying performance issues that would have been identified if the system had been sufficiently tested upon completion of installation.

The pilot project also highlighted the increased need for investment into education and training across all levels of the irrigation sector. From regional council, to farmers, their staff and contractors, through to service companies and their employees. Each has a part to play in the overall efficient use of water on farm. The challenge, is getting cross-sector understanding of the dynamic nature of irrigation, the regulatory implications, and the limitations and risks of what good management practice looks like.

Farmer engagement

ECan, along with industry consultation, set the project targets at 150 irrigated farms in the Ashburton zone, testing a maximum of 2 irrigation systems per farming unit (300 systems). The students achieved 87% (131) of the target farms and 81% (244) of the target systems. These results are viewed as excellent given need for a reasonably narrow range of the climatic conditions in which valid evaluations can be undertaken.

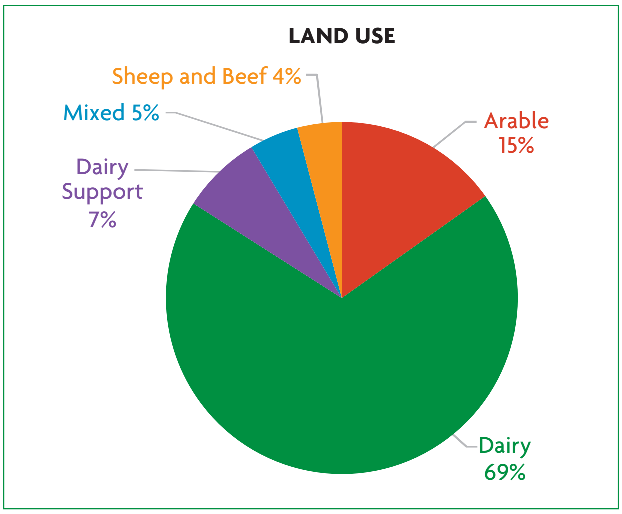




CHALLENGES ENCOUNTERED BY THE STUDENTS INCLUDED:

- Daily climatic variability
- Daily on-farm activities
- Students ability to clearly promote the value of the project
- Ability of the allied parties to clearly define and promote the value of the project
- Media promotion before the project starting
- Farmer caution regarding the intent of the project

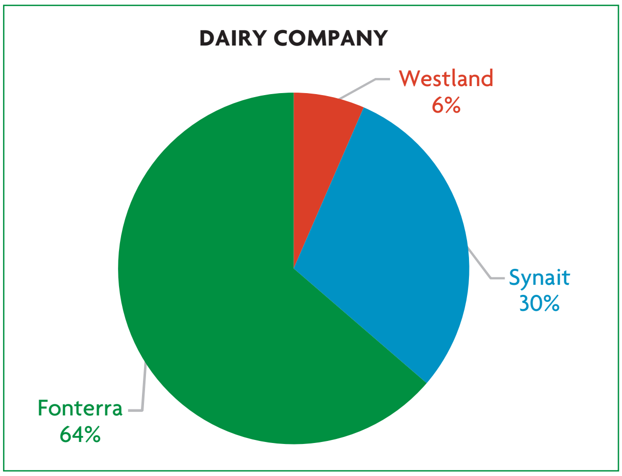
Land use and water source

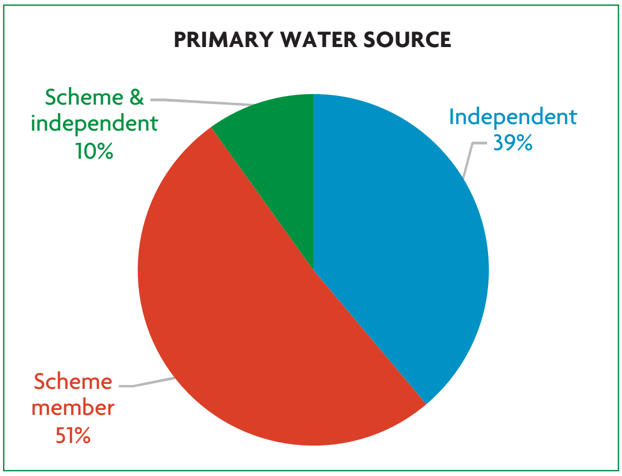


The project looked at all land use types and production systems within the Ashburton zone. Once dominated by Dryland/mixed arable production and sheep and beef based systems, the last 20 years has seen a large swing towards a grass based dairy system. High returns, access to irrigation, and a simplified business risk model has made dairy attractive when compared against many other traditional production systems. This land use change has been associated with a significant investment in centre pivots which have the potential to achieve much greater water use efficiency than the systems they replaced. These new systems are much less labour intensive.

Breakdown of the dairy companies operating in the Ashburton zone follows the expected trend with Fonterra being the longest established milk company followed by Synlait and Westland.

Analysis of on-farm water sources illustrates the important role played by irrigation schemes. These schemes supply alpine surface water which has helped to reduce the pressure on the groundwater system.





Systems tested and test conditions

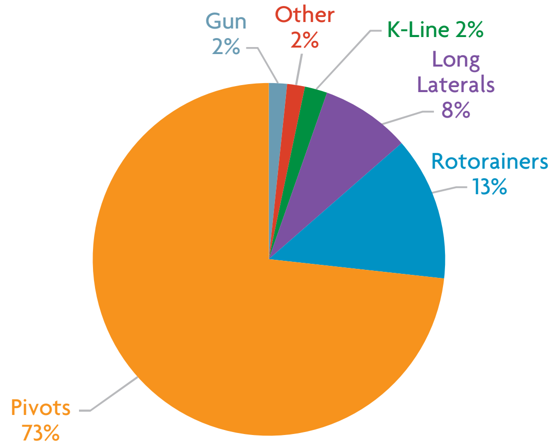
All irrigation system types were tested excluding Border Dyke. Border Dyke was excluded as testing this irrigation system requires considerable expertise. Systems tested included centre pivots, lateral moves, travelling irrigators, hard hose guns, and sprayline systems.

Centre pivots now dominate the Ashburton zone. The observed trends in the zone are:

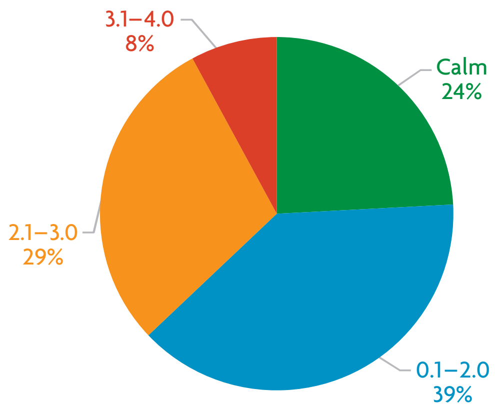
- Centre pivots are replacing less efficient/older system types over time, most notably RotoRainers.
- All other system types are typically infill irrigation within the larger irrigation area or specifically for small or dimensionally challenging paddock/fields. These percentages are not likely to change over time.

For an irrigation system to be effectively evaluated, the testing must be carried out under suitable climatic conditions. In Canterbury, the single biggest limitation on efficiency testing is wind. A valid evaluation cannot take place if the wind speed is greater than 4.0m/sec. The students, during the training phase of the project, tested several irrigation systems at wind speeds greater than 4.0m/sec then again within the valid testing limits. When the results were compared it clearly demonstrated the dramatic effect wind speed above this threshold has on the evaluation results. The students conducted 63% of the evaluations within wind speeds that would have a zero-net effect on the test results, 29% of evaluations at wind speeds that would have a minimal effect on the test results, and 8%of evaluations near the upper limit.

SEGMENTATION OF IRRIGATION SYSTEMS



WIND SPEED DURING TESTING (M/SEC)



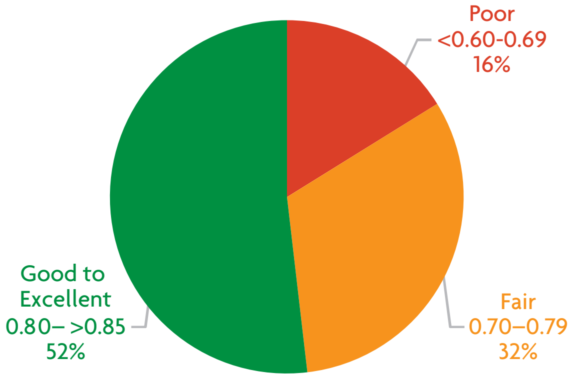
Irrigation systems performances

A key indicator for irrigation efficiency is **Distribution Uniformity**. This is the measure of how evenly the irrigation system applies water along its wetted length. Poor distribution uniformity creates uneven irrigation and production issues. It is widely accepted that for efficient irrigation distribution uniformity must be at least 0.80 or higher. However, not all systems are physically capable of achieving high distribution uniformities. This is performance limit is not confined to older irrigation system types like RotoRainers. Centre pivots longer than 800m, centre pivots shorter than 300m, and poorly maintained irrigation systems all suffer from distribution uniformity performance issues. Of the tested system types, 52% achieved good to excellent distribution uniformity, 32% achieved fair distribution uniformity, and 16% had poor distribution uniformity.

THE COMMON LIMITING FACTORS INCLUDED:

- Worn componentry including nozzles and pressure regulators
- Sediments and foreign particles in the water supply
- Incorrect hardware installed

DISTRIBUTION UNIFORMITY (ALL SYSTEMS)



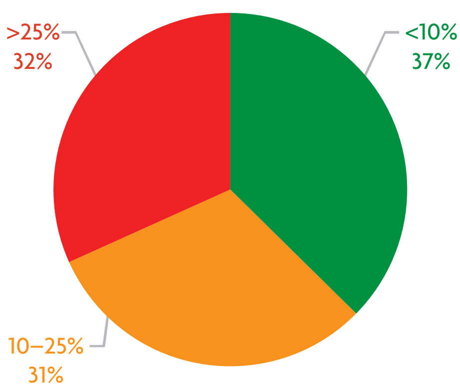
Another critical performance factor is **Application Depth**. All irrigation systems apply a depth of water to the soil to recharge the soil water content that has been used by the plants or evapotranspiration. If the irrigation system does not deliver the desired application depth, soil water levels will not be recharged to the appropriate levels leading to crop yield loss and/or losses of water from the soil profile.

Of the tested systems, 37% achieved +/-10% of the desired application depth, 31% achieved +/-25% of the desired application depth, and 32% achieved >+/-25% of the desired application rate.

LIMITING FACTORS INCLUDED:

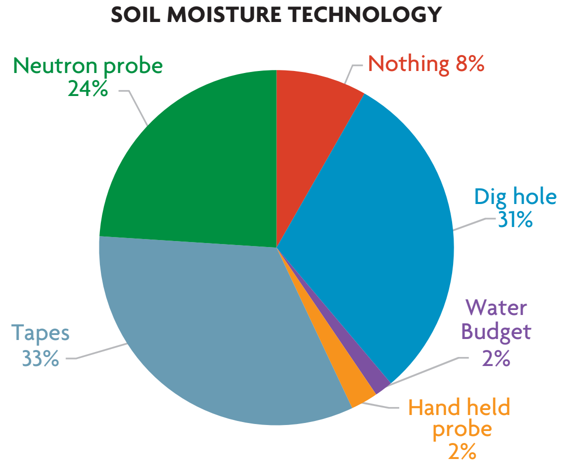
- Incorrect componentry installed
- Incorrect setup/commissioning at installation
- Pressure and flow issues caused by worn componentry or modification
- Poor/little understanding of systems constraints
- Poor maintenance
- Technology failures

APPLIED DEPTH (MEASURED)

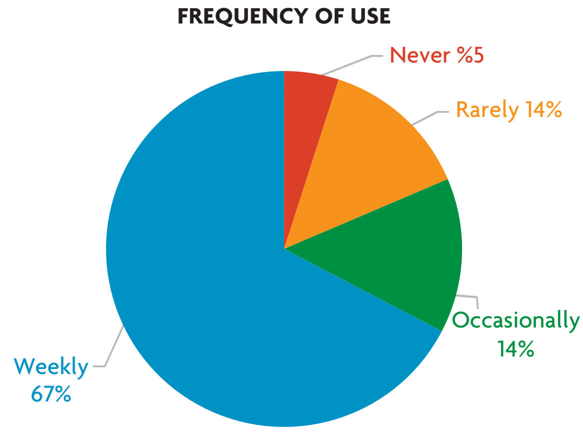


Use of soil moisture technology

Assessment of soil moisture levels is paramount for efficient irrigation scheduling. Knowing when to irrigate and how much to apply is fundamental practice to achieve a crop yield potential and to limit the potential effects of irrigation on the environment. The project looked at what systems were deployed on-farm to assist in the decision "Should I irrigate today?". The project suggests that 92% of irrigating farmers are using some form of information based system or technology to assist in irrigation schedule management.



For soil moisture tapes and neutron probe soil moisture monitoring systems, the project looked at the frequency of use and the barriers (if any) to the adoption of these technologies. Of the farmers deploying these technologies, 67% of farmers use it on a weekly basis to support their irrigation scheduling decisions, 28% us the technology rarely or occasionally and 5% did not use it.

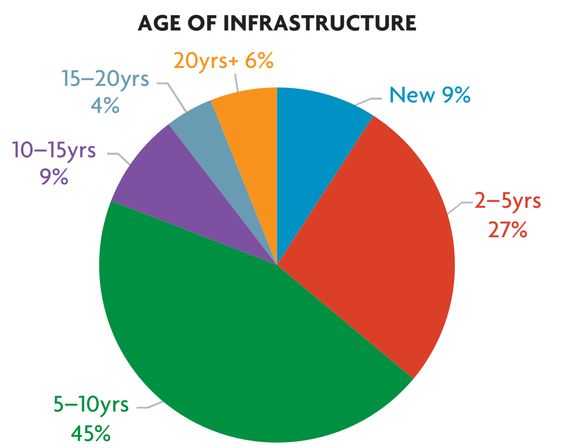


FACTORS INFLUENCING DISENGAGEMENT FROM THE INSTALLED TECHNOLOGIES:

- System/technology failures
- Poor installation
- Poor service from installation company
- Following known weekly irrigation and climatic trends

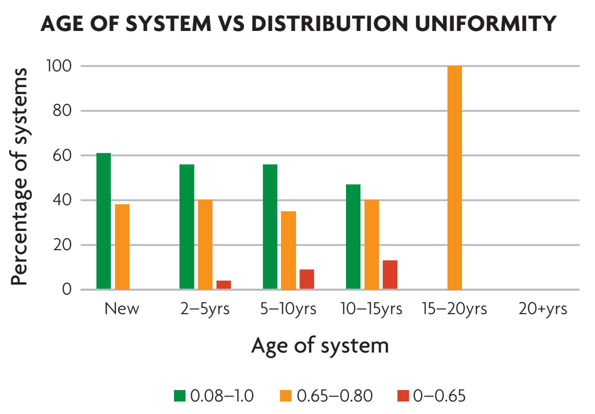
Age of infrastructure

This analysis highlights the growing importance of irrigation to the modern farming system. It also gives insight into the shifting nature of the irrigation service industry. Over time, the 'new sales' environment will mature into a service based model and eventually into an infrastructure replacement business model.



Given centre pivots occupy the greatest percentage of irrigated area within the Ashburton zone. The project analysed the age of centre pivots tested compared with their overall distribution uniformity.

The data suggests, that over time, the centre pivot performance deteriorates, with many systems performing quite poorly beyond 10 years of age. This suggests the need for better maintenance programmes and consideration to be given to significant component or whole system replacement as part of a system lifecycle, rather than assuming the system will persist and preform perpetually.



Case study 1

Irrigation system: 660m centre pivot

Typical application depths applied: 5–15mm (1–3–day return interval)

The centre pivot was tested in near ideal conditions at an application target depth of 9mm. From the bucket test data, there are several performance issues effecting this machine. Application depth was measured at 5.49mm (61% of the desired depth). Overall distribution uniformity was measured at 0.45, which is considered a poor result. In real terms, for this irrigator to achieve the intended application depth across most of the wetted area, the operator would have to apply 13mm. This increases the overall water use by 45%. This would lead to either crop production stress or seasonal water allocation issues.

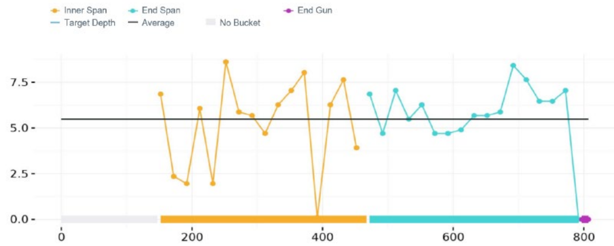
The test results were examined by IrrigationNZ and it was determined that the pressure regulators were failing, the centre pivot was not operating at the designed pressure, it also had some other minor maintenance issues.

The suggested remedial work was carried out and the system retested. The second test was conducted during a peak irrigation period which meant the desired application depth had been lifted to 15mm.

The measured application depth showed a significant improvement, it achieved 15.1mm or 100% of the desired target.

Distribution uniformity was calculated at 0.83 which is considered excellent.

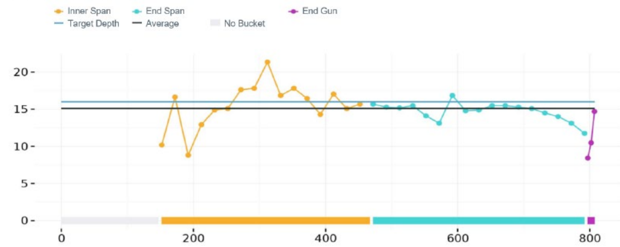
APPLIED DEPTH



RESULTS

Sections	Distribution Uniformity (DU)		Applied Depth Average (mm)		Intensity (mm/hour)
Pivot	**0.45**	N	**5.49**	N	
Pivot - Inner Span	0.31	N	5.21	N	
Pivot - End Span	0.66	!	5.76	N	28.93
Endgun			0.00	N	

APPLIED DEPTH



RESULTS

Sections	Distribution Uniformity (DU)		Applied Depth Average (mm)		Intensity (mm/hour)
Pivot	**0.83**	Y	**15.10**	Y	
Pivot - Inner Span	0.74	!	15.53	Y	
Pivot - End Span	0.90	Y	14.70	Y	47.44
Endgun			11.19	N	

Case study 2

Irrigation system: 470m Centre pivot + 82m corner arm

Typical application depth applied: 5–15mm (1–3–day return interval)

The centre pivot was tested in ideal conditions at a target application depth of 15mm. The manager, who also used soil moisture monitoring technology, had noticed prior to testing that soil moisture sensor data was suggesting the irrigator was applying less than the desired depth. The bucket test confirmed that the actual application rate was 10mm (68% of the desired application depth). The overall distribution uniformity was calculated at 0.71, this is considered fair result. In real terms, for this irrigator to achieve the desired average application depth of 15mm 21mm would have to be applied perevent.

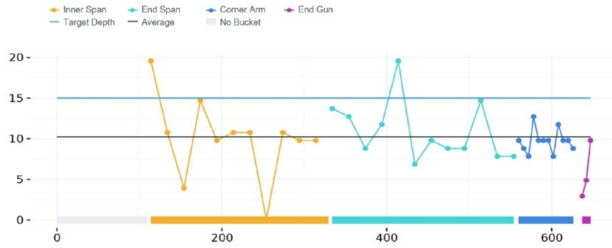
The test data was examined by IrrigationNZ and it was determined that the systems programmable calibration setup was incorrect in terms of runtime, some other minor issues were also identified.

The manager organised the irrigation service company to check the programmable calibration setup and correct any errors. The manager also repaired sprinklers and hoses that were identified from the evaluation.

The system was retested after the repairs had been completed and the results compared. The measured application depth was calculated at 14.85mm (99% of the target depth), and the overall distribution uniformity calculated at 0.85 which is considered excellent.

Both the results are significant improvements, in terms of application depth and the distribution uniformity, both have increased to the desired benchmarks. These systems are now applying water efficiently, which has productive, financial and environmental benefits.

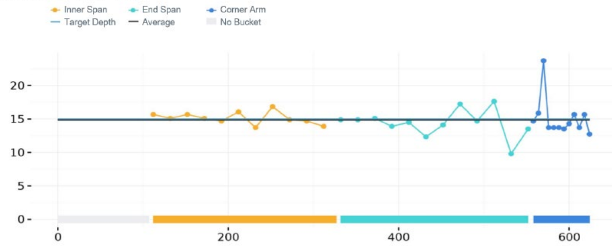
APPLIED DEPTH



RESULTS

Sections	Distribution Uniformity (DU)		Applied Depth Average (mm)		Intensity (mm/hour)
Pivot + Corner Arm	**0.71**	!	**10.24**	N	
Pivot + Corner Arm + Endgun	0.66	!	9.90	N	
Pivot - Inner Span	0.60	N	11.48	!	
Pivot - End Span	0.76	!	9.64	N	31.41
Corner Arm	0.84	Y	9.71	N	31.64
Endgun			5.87	N	

APPLIED DEPTH



RESULTS

Sections	Distribution Uniformity (DU)		Applied Depth Average (mm)		Intensity (mm/hour)
Pivot + Corner Arm	**0.85**	Y	**14.85**	Y	
Pivot - Inner Span	0.93	Y	15.11	Y	
Pivot - End Span	0.83	Y	14.38	Y	36.61
Corner Arm	0.88	Y	15.08	Y	38.40

Students’ conclusion

The 2016–17 bucket testing program covered many different land uses, and system types within the Ashburton zone.

During the programme, information about the specific system and farmer practice was compiled. This allowed trends to be identified from the collated data. In general, farmer engagement and participation has been encouraging with positive feedback being received from the farmers.

From the analysis trends in system performance were identified and the results summarised and presented back to the farmers who participated. Five farmer workshops were held to allow farmers to discuss issues highlighted by their evaluations. These workshops were run in conjunction with IrrigationNZ. From these workshops and the ensuing discussion, potential causes of any problems identified were identified. Recommendations were made about how improvements could be made, including the need for further analysis in some cases.

Farmers with poor system performance were contacted later to see if any improvements had been made. Some of these systems were then re-tested. However, unfortunately due to unfavourable weather conditions later in the period of this programme, it was not possible to re-test many. The systems that were re-tested showed significant improvements in system efficiency and highlighted the importance of doing these tests.

The Bucket testing methodology used, proved that the Check It Bucket Test app, designed by IrrigationNZ, provides valuable information and allows farmers to identify potential issues with their irrigation assets.

IMPROVEMENTS FOR THE PROJECT:

- Complete testing kits for all student’s c/w;
  - — 100 buckets/student
  - — Pressure gauge kits
  - — Temp/wind meters
- More upfront evaluation training
- Increase system evaluation capability of the app.
- FAQ sheet from previous year