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SCADAFARM – USING THE CLOUD TO IMPROVE IRRIGATION MANAGEMENT ON NEW ZEALAND FARMS

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SCADAfarm is an innovative monitoring and control platform developed right here in New Zealand. It is designed to help farmers observe and understand their irrigation activity in a way that supports and facilitates improved irrigation practices. In this paper we present recent developments in two specific areas, namely (i) soil moisture monitoring and (ii) irrigation performance monitoring, both utilising the SCADAfarm platform.

Soil Moisture Monitoring

Soil moisture monitoring has always been an invaluable tool for matching water applications to plant requirements and help maintain or improve irrigation efficiency. Without feedback on soil moisture, effective daily irrigation decision-making is challenging at least, and waste highly likely. Over-irrigation is clearly a leading cause of increased leaching and runoff on intensively farmed land when compared to its un-irrigated counterpart. Achieving GMP and improving irrigation efficiency will invariably lead to reduced environmental impacts.

Despite this clear need for monitoring, soil moisture monitoring technology has really only gained significant traction in the pastural-farming sector within the last decade or so. This uptake has been partly fueled by the wide-spread rollout of Farm Environments Plans nationwide, and the increased need for irrigators to be able to *demonstrate* GMP. Although results have been mixed, it has resulted in the irrigation industry moving in a positive direction overall. There is currently momentum for change, but the direction of this change has yet to be fully mapped.

Whatever technology is available, water management will only be effective when there is unsolicited engagement and buy-in from operators and managers. Above all, the technology must be reliable and fully trusted by users, as important daily decisions affecting profitability depend on its accuracy. One method of soil moisture monitoring that has been available for several decades and is well-proven to be accurate is the *water-balance* or *water-budget* model. It calculates the prevailing water balance state of soil by assessing concurrent water fluxes due to incident rainfall, irrigation activity and daily plant water requirements. The soil water balance is usually calculated once daily, but more frequent calculations may also be undertaken if required.

It is important to note that *water-budgeting* is a model, and like any model relies heavily on the accuracy of collected data used in its algorithms. Weather determines the daily plant water requirements (mostly through evapo-transpiration) and is arguably best assessed via an appropriate weather station network, as local topography often leads to microclimates which modelling may not account for. Similarly, local rainfall is best assessed with physical rain-buckets which can, where needed, be co-located close to irrigation equipment simplifying data connectivity.

Precision irrigation data is crucial to accurate *water-budgeting*, and this is where SCADAfarm steps up. SCADAfarm performs this data acquisition facility constantly in the background, simultaneously collecting irrigation, weather and other important metadata (eg: soils and plant information) and directs this to a central historian (Cloud storage). SCADAfarm is also the platform for data manipulation and ultimately data display. Data is redirected to the operators iphone or PC where arguably most daily decision-making occurs. Finally, SCADAfarm provides the control platform, allowing the operator to remotely make those changes necessary for effective water management. All the while, these changes are also constantly monitored. A typical SCADAfarm water-budget trace for a full-circle centre pivot is shown below.

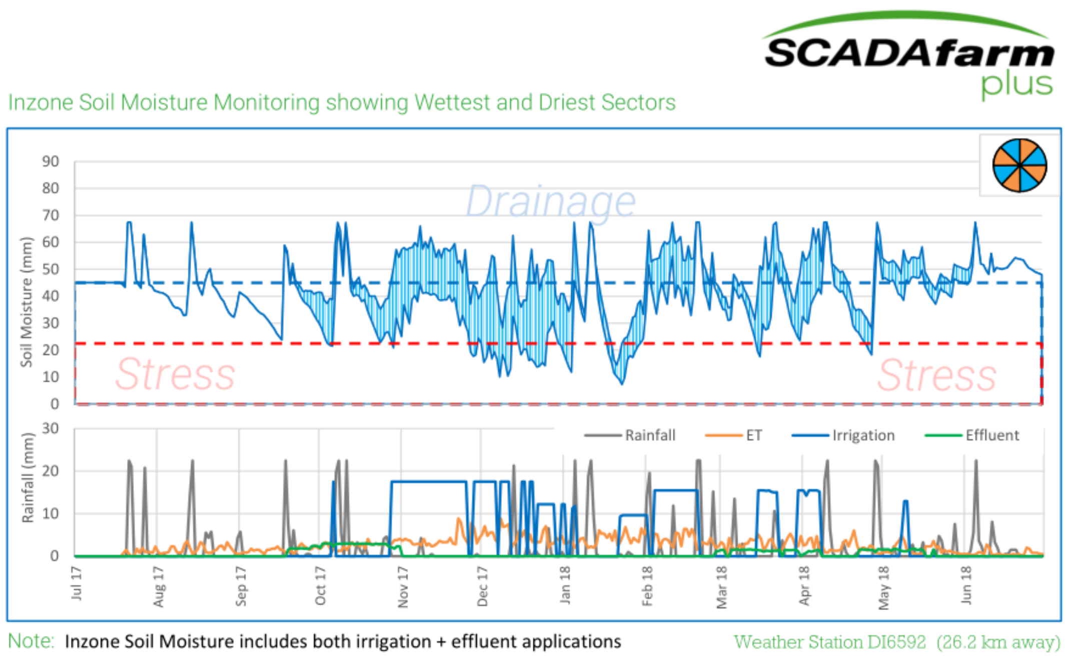


Figure 1: Inzone soil moisture monitoring over a season using a standard water-budgeting model

Points of note include;

- This budgeting model allows overshoot of soil moisture past field capacity (45mm). This potentially allow evaluation of runoff and drainage volumes.
- The pivot has been sectored into 8 wedges, each independently water-budgeted. The top water budget trace simultaneously displays the wettest and driest sector soil moisture values for each calendar day. Sectoring such as this is important for irrigators that target irrigate a portion of the pivot circle.
- There is ample evidence that irrigation has been stopped around significant rainfall events.
- Prolonged dry spells through November and February resulted in inadvertent over-irrigation as indicated. This may not have been picked up via ground probes
- Effluent was applied through May when soil moisture was high after rainfall. This should probably have been deferred to later in the year.

A feature in support of the *water-budgeting* methodology is its quantitative character. What is meant by this is that because the algorithm deals with water flux moving in and out of the soil profile, volume change may be calculated. Consequently, where field capacity is exceeded due to heavy rain or over-irrigation, drainage and/or runoff volumes may be assessed. This quantitative aspect is not available with conventional soil probes. It is intended to develop the water-budgeting methodology to assess these volumes and attempt to validate them with collected field data. The final aim is to demonstrate the viability of water-budgeting for assessing N & P leaching/runoff from irrigated land and provide further insight into the impact of irrigation management on these factors.

Irrigation Performance Monitoring & Proof of Placement

Data collection and hosting services are clearly bringing value to the agricultural market. The challenge is to ensure the farmer is not overloaded with copious data, whilst being provided with useful and meaningful metrics that facilitate positive changes in irrigation practice. The following section details some of the latest irrigation monitoring services that SCADAfarm provide, especially the proof-of-placement platform for fresh water and effluent application to land and describes some of the novel metrics currently under development. The importance of retrospective analysis and active user engagement is also be touched upon.

Historically, *proof of placement* (POP) was developed for tracking fertiliser application to ensure correct application rates were being adhered to and that farmers were obtaining value from their fertiliser spend. POP is now recognised as a powerful tool in assessing the environmental risk associated with fertiliser overapplication and potential nutrient loss to groundwater and waterways.

SCADAfarm irrigation monitoring builds on proven POP principles but extends to all forms of irrigation on farm, *viz* farm effluent, freshwater & fertigation. Constant monitoring of all relevant irrigation data including depth applications and field position allows both a temporal and spatial picture of applications to be constructed across the season. Both in terms of hydraulic (water) loadings, and embedded nutrients.

An example of cumulative hydraulic loadings for both cleanwater & effluent irrigation under a centre pivot is shown below.

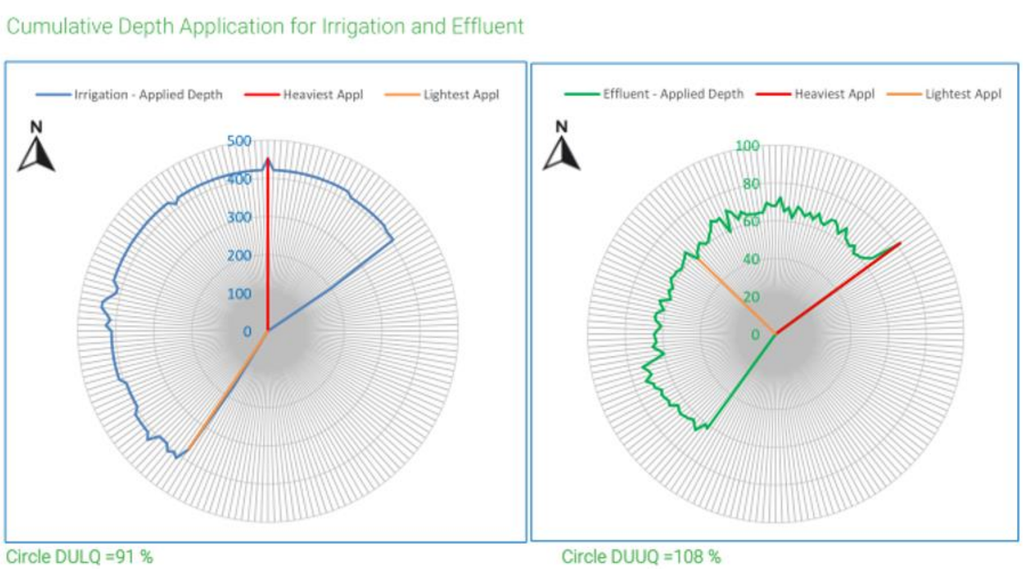


Figure 2: Spatial (radial) representation of irrigation applications over a season

Not only are there clear benefits associated with such simple data visualizations, but uniformity metrics may also be applied with benefit (DULQ & DUUQ as in this case). For pastoral farmers, a high level of circle uniformity is desired, whereas cropping farmers who often exercise a degree of "irrigation sectoring", circle uniformity is less relevant.

An important aspect when developing metrics intended to engage and promote GMP is with benchmarking. Benchmarking provides a vital reference point or level against which operators can make more informed decisions "on-the-fly". It also allows a degree of assessment when inspecting irrigation data at seasons-end. A demonstration of these principles is illustrated below. Monthly applied applications of water and effluent are benchmarked against "Estimated Irrigation requirements" calculated from a standard water-balance model specific to the farm location and the season. A local weather station (or surrogate weather-data platform) provides all weather data needed for this model.

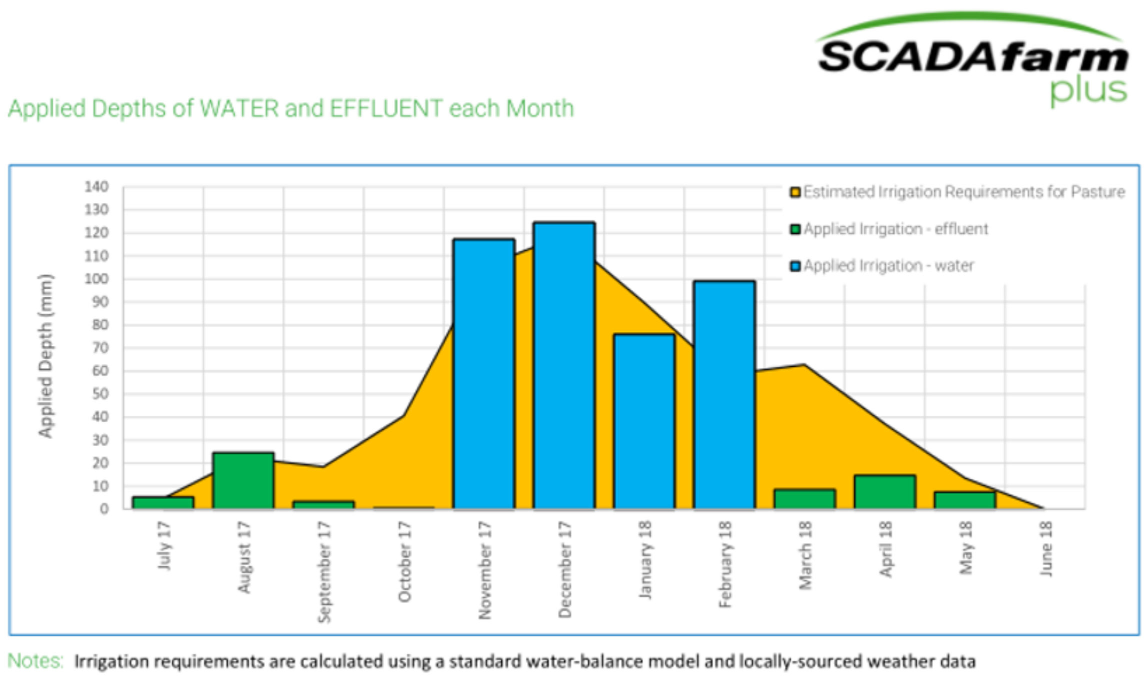


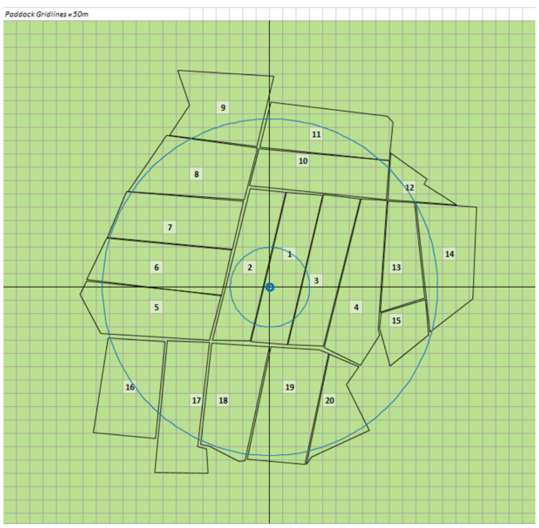
Figure 3 Monthly hydraulic loadings from both irrigation and effluent applications

It is evident in this case that applications have tracked reasonably well against calculated requirements, though they appeared a little light on the shoulders of the season (Sept/Oct & Mar/Apr). Although this type of benchmarking appears extremely useful, it can be somewhat misleading, as the "temporal character" of applications is not considered within any one month. For example, a period of "heavy irrigation" sustained for just a few days can easily skew results. This is where the benefits of soil moisture monitoring (as a metric for assessing GMP) really comes to the fore (refer to *fig 1* above).

On farms where regular applications of effluent are made to land, it is important to track applied effluent to ensure that consent limits are not being exceeded, and that GMP is being adhered to. In particular, it is important to track the hydraulic fraction of applications since there needs to be a soil moisture deficit present to prevent loss of embedded nutrients to water whenever applications are made. This hydraulic fraction is evident in the column graph above (fig 3), but the ultimate, again is to track soil moisture levels over the period of active irrigation. It is noted that the soil moisture calculated in figure 1 has also included this hydraulic contribution from effluent.

Ultimately it is the nutrient loadings to land brought about by irrigation activity that is of great interest and importance. Nutrient loadings generated via effluent irrigation or fertigation requires of course knowledge of both hydraulic loading levels and nutrient concentrations in the applied liquid. Many farmers are now required, as part of their consent conditions, to arrange for the assessment of nutrient levels in applied effluent. Typically, sampling from the effluent mainline might be carried out by the farmer monthly or bi-monthly and sent for lab analysis.

In such cases where concentration data is available, effluent monitoring via SCADAfarm may be coupled with this data and readily used to calculate applied nutrient levels. Where GIS data is available for defining paddock boundaries, nutrient applications per paddock may be readily determined. An example of such analysis for Total-N application is demonstrated below.



Nitrogen Report for

Summary Period:

Paddock Reference	Paddock Name	Paddock Area(ha)	Actual Area Irrigated(ha)	Applied N Rate (kg/ha)	Total N Applied (kg)
1	Padd 1	7.86	4.14	15.01	62.12
2	Padd 2	7.95	5.20	13.47	70.00
3	Padd 3	7.87	7.40	16.35	121.07
4	Padd 4	8.88	8.87	17.56	155.74
5	Padd 5	8.9	7.72	12.12	93.55
6	Padd 6	8.39	7.90	11.90	93.96
7	Padd 7	8.38	8.21	12.07	99.10
8	Padd 8	8.37	7.50	12.82	96.16
9	Padd 9	8.28	1.60	13.76	21.99
10	Padd 10	7.31	7.26	14.41	104.64
11	Padd 11	8.07	3.72	14.41	53.57
12	Padd 12	2.27	0.63	14.08	8.90
13	Padd 13	5.23	5.24	15.86	83.14
14	Padd 14	8.27	1.68	16.44	27.61
15	Padd 15	2.95	2.95	19.60	57.79
16	Padd 16	8.23	3.29	13.48	44.39
17	Padd 17	8.08	5.10	14.08	71.81
18	Padd 18	8.06	7.77	14.29	111.08
19	Padd 19	9.52	8.90	16.03	142.64
20	Padd 20	4.73	4.28	17.44	74.58

Figure 4 Total-N applications per paddock resulting from effluent applications

There are many advantages in making this sort of nutrient data available to farmers. Importantly they can see whether they are close-to or exceeding consent limits on a paddock by paddock scale. Farmers are also able to moderate fertiliser applications in a way that reduces nutrient loss on a very small scale instead of treating each land management unit (which may involve large land area) as a single entity. Finally, this sort of platform helps benefit those actively working to reduce nutrient loss by providing proof of GMP, or just proof of active nutrient management.