MANAGEMENT/MONITORING OF IRRIGATION REUSE

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BACKGROUND

The EPA's preferred strategy for wastewater involves treatment, storage and reuse via irrigation on land.

Key principles for operation of a reuse system are:

- Water is utilised by the plants being irrigated.
- Plant demand drives water use, not the need for lagoon storage.
- Facilities for wastewater storage and irrigation should contain all wastewater, irrigation run-off and contaminated stormwater in at least the 90th percentile wet year (SEPP Waters of Victoria, Clause 22(b)(i)).

A lot of effort and emphasis is placed on predicting the required irrigation area and storage volume using complex models. However, the proof of whether a system is working is in the operation.

Wastewater irrigation follows the same principles as other commercial irrigation. A common mistake when irrigating with wastewater is to try and treat it differently.

The aim of this paper is to outline some simple spreadsheet tools that can be used to monitor storage volumes and the soil water balance. These will:

- Enable accurate irrigation scheduling (so that plants are irrigated according to demand).
- Provide a record of irrigation, weather data, storage inflows and storage levels.
- Check actual performance against "design".
- Provide projections of winter storage levels and therefore planning can occur to ensure an empty storage prior to winter.
- Determine levels of seepage from the storage.
- Check the accuracy of meter readings.

Also, when an emergency discharge is anticipated, the data recorded by the monitoring tools can be used to demonstrate that a 90th percentile wet year is being experienced and that every reasonable attempt has been made to reuse the wastewater in a sustainable manner.

1.0 MAXIMISING CROP WATER USAGE

In determining the storage volume and irrigation area required for a reuse system a number of assumptions are made regarding plant demand. To ensure that these assumptions are valid, the system needs to be managed appropriately, as management has a dramatic impact on plant growth and hence on plant water use.

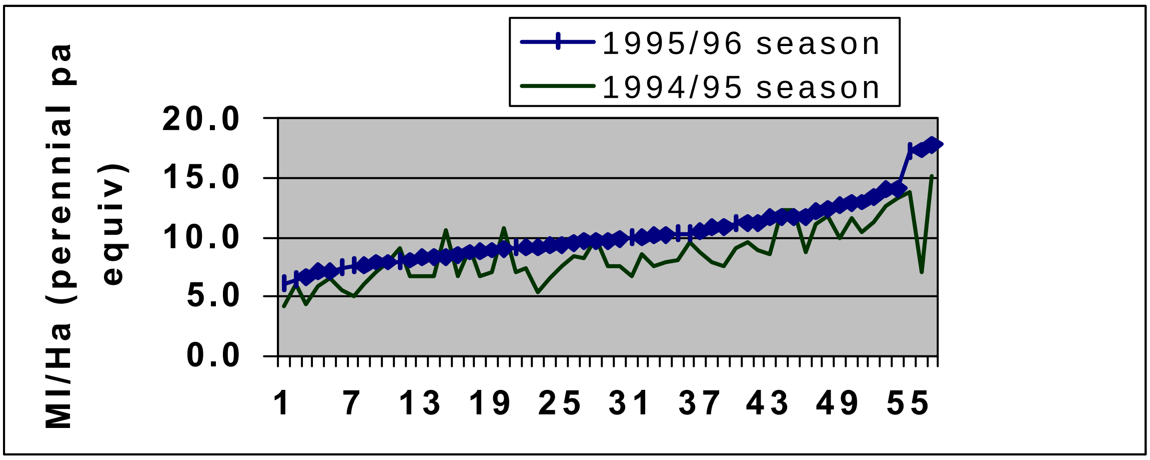
To maximise plant production and therefore water use, the wastewater must be applied when the plants need it. This will ensure that the plant's green leaf area is maximised and consequently the water use by the plant is maximised.

Under-irrigation reduces plant growth as they do not have access to sufficient moisture.

Over-irrigation, particularly in wet years, will also decrease the green leaf area because the waterlogged conditions impede plant growth. This will result in decreased water use by the plant.

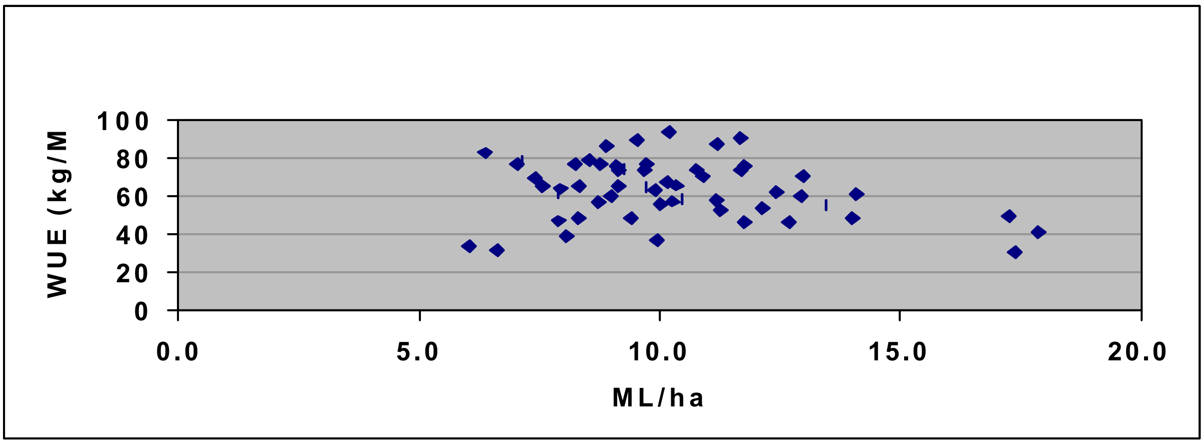
A study undertaken by DNRE regarding Water Use Efficiency, showed a range of irrigation intensities for 57 dairy farms in the Goulburn Valley.

Figure 1: ***Range in Dairy Irrigation Intensity (57 properties)***
Source: Adapted from DNRE Water Use Efficiency project (Armstrong et al)



These irrigation intensities can then be compared to water use efficiency (ie. production per ML), via the graph below.

Figure 2: ***Water Use Efficiency V's Application (ML/ha)***



Source: Adapted from DNRE Water Use Efficiency project (Armstrong et al)

This demonstrates that water use efficiency peaked on properties that had intensities of around 9 – 10 ML/ha, which is approximately equivalent to the predicted irrigation requirement in this area. As intensity increases, it appears water use efficiency began to decline (ie. over-irrigation and runoff occurred).

Through knowledge of crop yields or stocking rates an operator can determine if water use is being maximised.

2.0 IRRIGATION SCHEDULING

A common cause of failure occurs when the principles of proper irrigation scheduling (ie. the amount and frequency of application) are ignored. A simple spreadsheet tool can be used to enable appropriate scheduling to take place.

Figure 3: ***Irrigation Scheduling Spreadsheet Formula***

Date	Daily pan evaporation	Crop factor	Crop water use (soil loss)	Effective rainfall	Daily gain/loss	Cumulative soil moisture deficit	Irrigation applied
	A	B	C = A x B	D	E = C – D	$F = E_1 + E_2 + G$	G

Operation rules for the spreadsheet are summarised as:

- The model is started following a rainfall that produces runoff (saturates the ground). On this date the soil moisture deficit is zero.
- Evaporation and rainfall are then recorded on a daily basis and entered into the relevant cells.
- When the soil moisture deficit exceeds 12 mm but is less than 50 mm, irrigate and replace all but 5mm of the deficit (note that these figures are an example only, they need to be set on a site by site basis).
- Record the amount of irrigation applied.
- The crop factor is set according to the crop being irrigated (pasture would initially be set at 0.7).
- The effective rainfall is initially set assuming the first 5 mm of any rainfall event is ignored
- The soil moisture deficit should be maintained at
  - closer to an ideal refill point (30 mm deficit) during Autumn and Spring to minimise the risk of waterlogging from rain
  - closer to field capacity (around 12 mm deficit) during Summer to allow for some margin in hot or windy periods
  - closer to a minimum (50 mm deficit) during periods of water shortage

Soil moisture monitoring (using tensiometers or equivalent) will allow the spreadsheet to be calibrated by adjusting the "crop factor" and "effective rainfall" parameters. The soil moisture monitoring will need to concentrate on the "wetter" areas to minimise waterlogging and accessions to the groundwater.

Use of this spreadsheet tool will ensure that irrigation scheduling is accurate. It is a best management practice.

3.0 MONTHLY WATER BALANCE

In addition to daily monitoring for irrigation scheduling purposes, a monthly water balance should be calculated as a method of managing storage levels.

As with the irrigation scheduling, a simple spreadsheet model can be developed to monitor the monthly water balance for a reuse system.

The aim of this water balance is to:

- Provide a record of irrigation, weather data, storage inflows and storage levels
- Check actual performance against "design"
- Provide projections of winter storage levels and therefore planning can occur to ensure an empty storage prior to winter
- Determine levels of seepage from the storage

Figure 3: ***Monthly water balance spreadsheet formula.***

Storage Surface Area (ha)	A
Wastewater Inflow (ML)	B
Rainfall (mm)	C
Rainfall (ML)	D = C x A x 0.01
Total Inflow (ML)	E = B + D
Evaporation (mm)	F
Evaporation (ML)	G = F x 0.8 x A x 0.01
Seepage (ML)	H
Irrigation (ML)	I
Total Outflow (ML)	J = G + H + I
Inflow - Outflow (ML)	K = E – J
Opening Storage Volume (ML)	L
Closing Storage Volume (ML)	M
Storage Change (ML)	N = M – L

Operation rules for the spreadsheet are summarised as:

- Record rainfall, evaporation, wastewater inflow, irrigation and storage volume on a monthly basis and enter into relevant cells
- Adjust seepage until "inflow – outflow" is equal to "storage change".

Levels of complexity can be added to this spreadsheet to:

- allow for multiple irrigation areas and/or storages
- predict the future storage volume using historic (average and/or wet year) climatic data and crop factors

Completion and use of the monthly water balance provides a planning tool for the reuse system. There are no surprises regarding what is to happen with the system.

4.0 MANAGING STORAGE VOLUME

The monthly water balance can be used to predict future storage volumes. This information can then be used to manage irrigation so that the storage is empty going into winter.

For example, the following practices can be used:

- at the start of the season the total area should be irrigated fully according to plant demand. (It is critical for the sustainability of the site that irrigation application does not exceed plant demand.)
- full irrigation should continue during the season, until the water balance monitoring clearly predicts that the storage will empty

- when it is clear the storage will empty (ie. in a dry year) a staged approach can be adopted:
  - firstly the area can be kept at a lower soil moisture status in case the season changes
  - then some areas can stop being irrigated as the available water declines (these areas should rotate from season to season to ensure an even nutrient application)
  - contingencies, such as supplementary feeding (grain and hay), are required for feeding later in the summer in a dry year, because pasture will be dried off due to a lack of water
- if monitoring shows that the storage will not empty (ie. in a wet year):
  - additional irrigation areas could be added (if available)
  - recorded data can be assessed to see if it is a 90th percentile wet year and a spill may be allowed

5.0 STORAGE SPILLS

The EPA have established that "spills" can occur 1 year in 10 on average, ie. in the 90th percentile wet year.

To date very few systems are fully land based and recent dry seasons have limited the need for spills, so the EPA has not been tested. It appears there is no system in place to ascertain when a spill can occur and how much the spill should be. The new draft guidelines totally ignore this aspect.

The monthly water balance can be used to both:

- predict when a spill may occur, and
- prove that it is a 90th percentile wet year and every attempt has been made to maximise reuse on the site (sustainably)

If a water balance is not undertaken, it would be difficult to argue with the EPA for a discharge.

Note that if a spill is likely and it is not the 90th percentile wet year, additional development may be required. Therefore the water balance can also be used for long-term planning.

6.0 METER READINGS

Undertaking a monthly water balance provides a method of checking the accuracy of meter readings.

If the change in storage level is not approximately equivalent to the difference between inflow and outflow, the flow meters (on either inflow or irrigation) may not be accurate.
This check gives confidence in the data recorded.

7.0 AUDITING/REPORTING

Best practice management of reuse systems requires a process of annual reporting.

This reporting would include site production, irrigation scheduling and the monthly water balance.

The tools outlined above provide the records required to undertake an audit/report on the reuse system.