New Zealand Piped Irrigation System Performance Assessment Code of Practice

PART C: Micro-irrigation

Note: This is Part C of a series of nine (Parts A–I).

Part C: Contents

Date of Issue: January 2023

The Code is presented as a series of booklets, each with a defined purpose.

Part A: An Introduction to Performance Assessment
Part A provides an overview of performance assessment, explains the broad philosophy behind assessment approaches taken throughout the Performance Assessment series, and contains specific formulae and reporting standards.

Part B: Compliance and Water Supply Checklists
Part B relates to all system types. It contains recommendations for checks to ensure compliance with regulations, rules and consent conditions, safe effective operation of water supply systems.

Parts C–H: System Performance Assessments
(Part C = this booklet)
Parts C–H contain guidelines and recommendations for Operational Checks, System Calibrations and In-field Performance Assessments specific to a range of irrigation system types.

Part I: Conducting Energy Efficiency Assessments and Seasonal Irrigation Efficiency

IrrigationNZ Technical Glossary
The Glossary and Calculations are common with the NZPIS Design Code of Practice.

Ministry for Primary Industries
Manatū Ahu Matua

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Introduction

Purpose

The *New Zealand Piped Irrigation System Performance Assessment Code of Practice* provides nationally recognised guidelines to measure and benchmark performance of agricultural and horticultural irrigation systems.

Part C is specific to micro-irrigation systems, specifically driplines and micro sprinkler systems commonly seen on orchards, vineyards and greenhouses. It makes recommendations for planning and conducting assessments and reporting on the performance of irrigation systems and their management. Its focus is on key performance indicators that are common with the New Zealand Piped Irrigation Systems Design Standards.

SYSTEM PERFORMANCE

The Code recognises different levels of performance assessment depending on purpose. In increasing level of complexity, system performance assessment includes:

- Operational Checks
- System Calibration
- Full System Performance Assessment.

Related documentation

- **New Zealand Piped Irrigation System Performance Assessment Code of Practice:**
  - Part A: An Introduction to Performance Assessment
    Part A provides an overview of performance assessment, explains the broad philosophy behind assessment approaches taken throughout the Performance Assessment series, and contains specific formulae and reporting standards.
  - Part B: Compliance and Water Supply Checklists
    Part B relates to all system types. It makes recommendations for checks to ensure compliance with regulations, rules and consent conditions, safe effective operation of water supply systems and energy efficiency assessments of pumps and delivery systems.
  - Parts C–H: System Performance Assessments
    Parts C–H contains guidelines and recommendations for performance assessments specific to a range of irrigation system types.
- **New Zealand Piped Irrigation Systems Design Code of Practice**
- **New Zealand Piped Irrigation Systems Design Standards**
- **New Zealand Piped Irrigation Systems Installation Code of Practice**
- **New Zealand Water Measurement Code of Practice**
- **New Zealand Irrigation Technical Glossary**

System description

A micro-irrigation system consists of a network of lateral pipelines fitted with low discharge emitters or sprinklers generally operating at low pressure. In this Code these systems will be referred to as drip/micro systems collectively.

Dripline can either be polyethylene laterals where drippers have been inserted individually to match the crop spacing or manufactured dripline where the drippers are moulded directly into the lateral at various spacings. Both these configurations can have pressure compensating drippers/emitters or non-compensating emitters.

Micro sprinkler systems use a polyethene lateral to supply small sprinklers often mounted on stakes connected to the lateral by off take tubes. Generally, these are designed to spray under the crop canopy around tree or vine bases. These systems are normally for Irrigation but in some locations may serve a dual purpose of providing frost protection.

For some drip/micro the design of the layout and system operation is characterised by watering only part of the total soil area, relying on soil moisture translocation to provide even coverage across the crop root zone and depth. In this instance the uniformity of application along the length of the crop row or irrigation lateral is critical to achieving good irrigation practice. Thus, Emitter Uniformity (EU) is measured. In systems that rely on the distribution of the water as a spray across a wider portion of the soil surface (for either irrigation or frost protection), good irrigation performance relies on the uniformity of distribution rather than the soil's textural characteristics to move water laterally. In this case Distribution Uniformity (DU) is critical and can be measured.

A complexity with dripline systems is that while most are mounted above ground, allowing direct access for measuring emitter outputs, some system designs have the dripline placed below the surface, for various reasons, such as better performance under high evaporation conditions. In these cases it is more difficult to determine Emitter Uniformity by direct volumetric measurement so the Code relies on measuring pressure at particular points in the laterals to determine alignment with the design key performance indicators. This indirect measurement approach relies on the fundamental relationship between pressure and flow for a given emitter orifice.

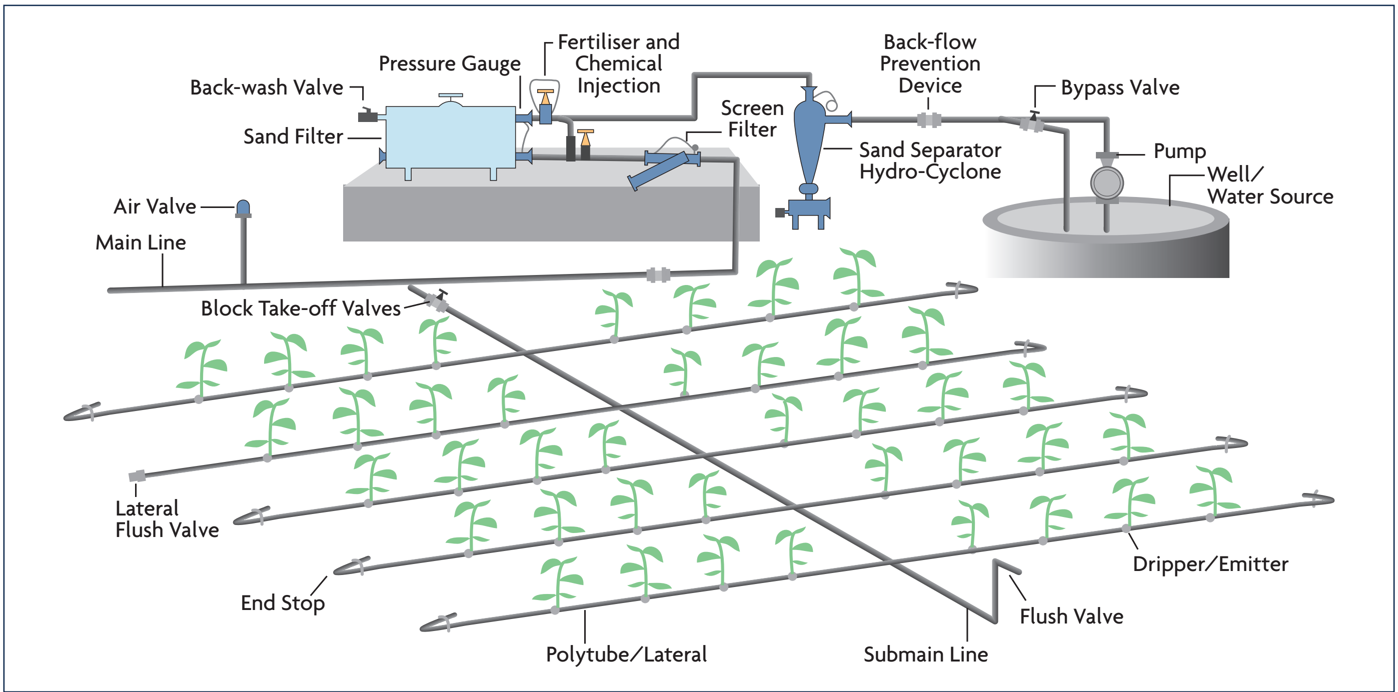

Figure C.1. Components and layout of a drip irrigation system. Based on a diagram from Jain Irrigation.

Special features for analysis

SOIL MOISTURE

The behaviour of water (lateral and vertical translocation) in a dripline wetted zone is influenced by conditions existing in the soil at the time (soils texture and soil moisture), and by previous irrigation practices (remaining water holding capacity and surface infiltration rates).

LOW OPERATING PRESSURES

Micro-irrigation systems usually operate at low pressures. This means a small actual pressure variation is large in relative terms, and can have a significant effect on flow variation. The Code particularly looks to determine if the pressure variations measured are within the original design tolerances. It is typical to see pressure gradients down drip/micro laterals but these may be acceptable for the design flowrates and emitter outputs, especially where pressure compensating emitters are used.

PRESSURE COMPENSATING EMITTERS

Pressure compensating emitters are designed to give a more even discharge across a wider range of working pressures than a non pressure compensating system design. Pressure compensating systems also provide better uniformity of discharge where significant elevation changes occur across a lateral block which is common in orchards and vineyards.

DISTRIBUTION/EMITTER UNIFORMITY

Overall field distribution uniformity of a micro-irrigation system is determined by variation in emitter discharge and emitter spacing .In a brand-new, well designed system, overall system performance is determined by accepted pressure variation within the lateral network, emitter performance (measured flow) and variation in manufacture.

In older systems, there is a focus on emitter uniformity which is calculated using measured flows from emitters but does not include outlet spacing for the uniformity calculation. Emitter performance is affected by damage to and deterioration of components, and by physical blockages of the very small orifices. The natures of the drip and micro sprinkler systems with very small orifices, requires that water quality be high.

PERMANENT SET SYSTEM

Because drip/micro irrigation systems typically have the emitters fixed In position relative to the plants, each plant receives water from the same emitter(s) each time it is irrigated. if there is non-uniformity in the system this means inconsistent discharge of water to certain plants is repeated every irrigation cycle. Thus, high uniformity is a critical design factor. There is no ‘smoothing’ effect to even out water application across a block as occurs with moving sprinkler systems, where emitter non-uniformities may cancel each other out in subsequent irrigation cycles. [However, see Parts D–H for other system types where it is shown this is an unreliable assumption for achieving good irrigation practice].

MULTIPLE OUTLETS PER PLANT

In many cases individual plants are served by more than one emitter. Even small drip-irrigated row crop plants can be considered to have multiple emitters if the wetted area per emitter is such that, if every other emitter was blocked, each plant would still receive some water. In most drip/micro systems, especially pressure compensated systems, the discharge that would have occurred from a blocked emitter does not subsequently get discharged as higher flow rates from unblocked emitters. While a plant may receive some water to keep it alive, it will likely suffer poor growth due to restricted water supply.

SMALL ROOT FRACTION WETTED

Most drip and some micro systems wet only a fraction of the available root area. Because most areas in New Zealand receive significant rain throughout the year, permanent crop root systems generally cover the entire field.

With only part of the ground area wetted by a drip/micro-irrigation system, the system design normally assumes a given volume of water per plant or area is discharged and then soaks and spreads further into the soil root zone. A good design will have analysed and taken into account the particular soil texture present in each part of the irrigation network. Care must be taken to avoid poor sideways distribution of water from point sources and excessive volumes applied to free draining soil textures that allow deep drainage losses.

SYSTEM VARIABILITY

The performance of drip/micro irrigation systems may vary at different positions in the field. Contributing factors include topographic variation and elevation changes, lateral pipe lengths, water quality and variable distances from headworks to lateral pipe inlets. In addition soil variability will likely occur across a field or multiple irrigation blocks. Variability in the system compounded by variability in soils and crop stages means the design and testing of the irrigation system needs to focus on removing as many system variables as possible. Direct measurement of EU and DU helps determine if the variations exceed the agreed design performance criteria that should have taken into account any physical limitations.

FIELD ELEVATION AND KPIS

If the field is level (i.e. minimal elevation changes), the hydraulically closest and furthest points from the zone valves will normally have the highest and lowest emitter pressures respectively. These will be sampled in positions in lateral lines as part of the basic testing procedure. While pressure variation may also occur down mainlines relative to the distance from the headworks, in most drip/micro systems the potential variation in block supply point pressures are set at the downstream side of a block valve.

If field elevation varies significantly, consider increasing the number of tests to increase accuracy of emitter uniformity assessments. Record the (relative) elevations of each test site, and draw a profile sketch along a typical lateral if necessary. This can then be related back to the design hydraulic grade line to see If the measured values meet the tolerances considered during the design phase.

Ideally a well-designed drip/micro system will have been fully tested and commissioned at the end of the installation process and all critical pressures will be noted in a well documented commissioning report. If these test pressure points are not documented the Performance Assessment process will require reverse engineering to understand if the values being measured in the field are acceptable or fall outside the equipment manufacturer design specifications. This is a complex process for drip/micro systems.

1. Operational checklist

This is a minimum list of checks that should be made for drip/micro irrigation systems.

Be safety conscious – electrical and mechanical hazards may be present.

Every system that conforms to the IrrigationNZ Design Code of Practice should be supplied with a System Operation Manual and a documented commissioning report that sets out critical flow and pressure measurement KPIs across the blocks. The manual may include extra checks not listed here. It will give more detail than this checklist including information specific to your system.

SYSTEM OFF CHECKS

Filtration

1. Check condition of filters and filter media
   - No leakage from seals or joints
   - Rings/screens are clean with no holes
   - Pressure gauges are fitted and in good condition.

Fertigation/chemigation

2. Ensure the system is physically sound
   - No signs of corrosion
   - System clean, no blockages
   - No leaks
   - Backflow prevention is installed as required.

Control valves and offtakes

3. Ensure wiring and hydraulic lines are secure
4. Ensure manual valves are correctly set

Flushing points

5. Check flushing points are accessible
6. Ensure caps are in place

Pipe network

7. Visually inspect sub-mains/headers as possible
8. Visually inspect laterals are undamaged. Note any that are broken or open and recommend the system owner has them repaired

Emitters

9. Check emitter fitted are as specified in the design
10. Inspect for damage or blockage
11. Inspect risers for wear or damage

Control unit

12. Visually inspect electronic controls
13. Check battery charge.

SYSTEM ON CHECKS

Pump

1. Complete checks as specified in *Part B: Water Supply Performance Assessment*

Headworks

2. Complete checks as specified in *Part B: Water Supply Performance Assessment*
3. Check the flow rate of each station

Pipe network

4. Check for leaks along mainline
5. Check for leaks along sub-mains
6. Check for leaks along laterals
7. Check laterals flush clear

System pressure

8. Check pump pressure for each station
9. Check pressure before and after filters
10. Check all off-take pressures correct
11. Check the lateral end-pressure
    - Test at ends of far laterals.

Emitters

12. Check all emitters/sprinklers are flowing
13. Check sprinkler parts are moving freely.

2. Calibrating micro-irrigation systems

The Irrigation Calibration method for drip and micro-irrigation systems assesses the mean depth of water being applied to individual irrigation stations (also called Zone or Block valves). It is based on measurement of flow from selected emitters and calculation of whole station Crop Applied Depth, Soil Applied Depth in the wetted area and Emitter Uniformity.

This allows the system manager to confirm the system Is applying the expected target depth as per the design , and whether the system is applying water evenly across the irrigation station.

By repeating the process in different irrigation stations, an assessment can be made of the ability of the system to meet the design intentions to apply targeted depths in each station across the whole property.

NOTE:
Refer to *Part A: An Introduction to Performance Assessment* for more information about calibrating irrigation systems.

2.1 What will the testing show?

The main things the calibration test will show are:

Mean station applied depth
The depth of water the irrigation system is applying on average to each station. Compare the measured applied depth to target application depth, The target application depth for each irrigation event is calculated by the operator/manager from rainfall and evapotranspiration for a given soil moisture holding capacity, Alternately, you may be able to compare the target depth applied per hour as per the system design specifications. . Station run times are set (durations and return intervals) to deliver the correct applied depths.

Soil applied depth
The depth of water (in mm) being applied to the total crop area actually wetted by the irrigation system.

Emission uniformity EU
The evenness of discharge from individual outlets. The higher the EU, the better the system is performing. And the higher the uniformity, the more confident you can be that sampled measurements are truly representative of the overall system performance.

Application intensity
The depth of water being applied per hour. This equivalent to the terminology used to describe a rainfall event In mm/hr.

Adjusted station run time
Calculates the irrigation duration to ensure 7/8ths of each Station gets at least the Target Application Depth. It accounts for design outlet spacing and flow rate across soil types and any variations in these factors or system distribution and emitter uniformity.

Target Depth ÷ EU = average mm required for 7/8ths to receive the target mm minimum.

EXAMPLE:

- 10mm target depth
- 0.7 EU
- 10mm ÷ 0.7 = 14.3mm

If the system applies on average 5mm/hr then the run time would not be 2 hours to achieve 10mm across 7/8ths of the crop but rather 2 hours 50 minutes to raise the average applied depth to 14.3mm thus ensuring that 7/8ths received 10mm minimum.

WHEN SHOULD CALIBRATION BE DONE?
Complete the calibration test if commissioning any new areas and after any major changes. Calibration should be repeated as part of system checks at the start of every season.

Drip/micro irrigation system performance is largely unaffected by weather conditions, with the exception of some micro spray systems where wind can affect spray patterns even when under the protection of the crop canopy. Performance can be influenced if system pressure significantly alters, such as if pumping systems are changed or bore levels drop.

2.2 Calibration process

Before starting, ensure System Operational Checks (Section 1) have been completed.

Calibration is a four step process:

1. Gathering information about the system design and KPIs (as-builts if held)
2. Calculating performance indicator values from collected field measurements
3. Comparing results with the design specifications (design specifications at commissioning or against commissioning reports if during maintenance)
4. Adjusting irrigation system settings as required to achieve intended performance or undertaking repairs and maintenance.

GATHERING INFORMATION

Equipment

Equipment needs are very basic and most should already be available on the property. A suggested list includes:

- Containers to collect water from outlets
  - 9 Litre buckets are good for sprinklers
  - 2 Litre ice cream containers are good for drippers
- 1 measuring cylinder
  - 1 or 2 Litre for high flows (sprinklers)
  - 100mL or 200mL for lower flows (drippers)
- 1 tape measure
- 1 stop watch
- 1 pen or pencil
- 1 recording sheet.

Sampling method

Calibration is based on measurements collected at specified locations within an irrigation station (Figure 2.1).

NOTE:
A "station" is a part of the irrigation system controlled as a single unit, typically by an off-take with a gate valve or solenoid valve. A station is also called Zone or Block valves in some design software tools. In each zone, 12 samples are taken as shown in the diagram below.

Follow placement instructions carefully and read volumes as accurately as possible to be sure of best results.

FIELD MEASUREMENTS

Repeat the following field measurements and calculations in each station of interest.

Emitter/sprinkler measurements

1. Measure the distance between outlets along a lateral. It is often best to use an average distance between a number of outlets
2. Measure the distance between adjacent laterals, usually adjacent rows. Take an average spacing between several laterals
3. Estimate the average width (below ground) of the wetted strip along each row. This will require some insight to the type of crop grown, its stage of growth and the historical placement of water that may have impacted lateral and vertical root growth patterns.
4. Determine the area of each station
   [Row length x row number x row spacing]

Application test

5. Collect the output from one emitter at the beginning, middle and end of the lateral nearest to the station inlet (Figure 2.1)
6. Measure the volume of water in each container and record on the record sheet
7. Repeat along two middle laterals
8. Repeat along the lateral furthest from the inlet.

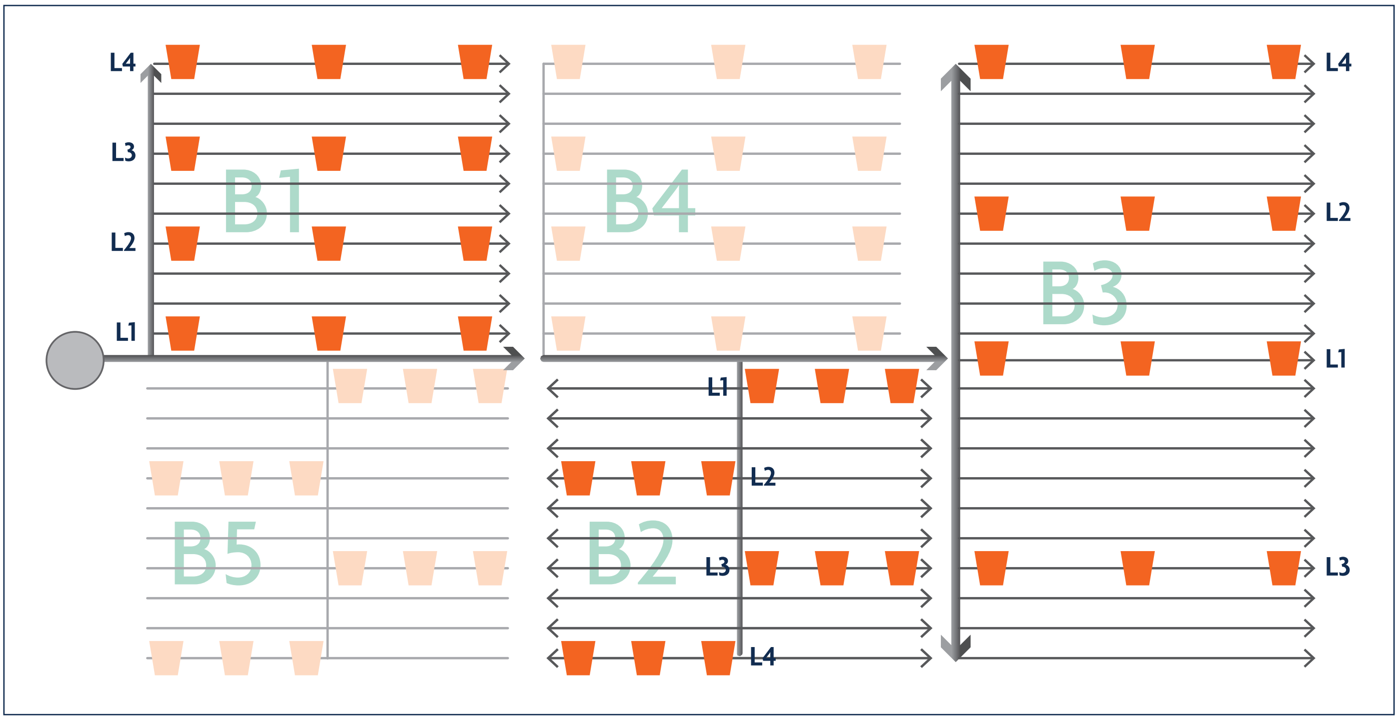

Figure 2.1. Recommended locations for emitter or sprinkler flow measurements for drip/micro irrigation calibration.

PERFORMANCE INDICATOR VALUES

Emitter or sprinkler flow rates

1. Calculate *Average Volume* collected (mL)
   [Average of 12 collected volumes]
2. Calculate *Average Emitter Flow Rate* (L/h)
   [Average volume (ml) ÷ collection time (min) x 0.06]

Application intensity

3. Calculate *Application Intensity* (mm/h)
   [Average emitter flow rate (L/h) ÷ (outlet spacing (m) x lateral spacing (m))]
4. Calculate *Station Flow Rate* (m^3/h)
   [Application Intensity x Station Area x 10]

Applied depth

5. Calculate *Mean Station Applied Depth* (mm) [Application Intensity (mm/hr) x Run Time (hrs)]
6. Fraction Wetted = Wetted Strip Width ÷ Lateral Spacing
7. Calculate *Soil Applied Depth* (mm)
   [Applied Depth x Fraction Wetted]
8. Fraction Wetted = Wetted Strip Width ÷ Lateral Spacing

   NOTE:
   Run Time (hrs) Is the duration of the Irrigation event to apply the Intended depth. It Is not the time taken to complete the test/collect the volume In the container.

Emission uniformity

9. Calculate the *Emission Uniformity*
   [Low quarter average volume ÷ average volume]
10. Calculate *Low Quarter Average Volume* (mL)
    [Average of lowest 3 emitter volumes]

    NOTE: 3 buckets is one quarter of the 12 samples collected.

COMPARE RESULTS WITH EXPECTATIONS

Flow rates

1. Compare *Average Emitter Discharge* to the manufacturer's quoted flow rate
2. Compare the calculated *Application Intensity* to expectations set out in the system design report or commissioning report
3. Compare calculated *Station Flow Rate* with *Water Meter Flow Rate*

Applied depth

NOTE:
Refer to the design report or commissioning report taking into account any return intervals.

4. Calculate *Target Depth to Applied Depth ratio*
   [Target Depth ÷ Applied Depth]
   - < 1 – under applying
   - = 1 – correct
   - > 1 – over applying

   Acceptable variances: 0.90–1.10 (0.95–1.05 is better)

Using the systems measured uniformity, you can calculate the required depth to ensure 7/8ths of the crop receives the minimum Intended depth.

5. Compare Soil Applied Depth with Soil Moisture Deficit
   ~ Soil Applied Depth < Soil Moisture Deficit ÷ EU

Example:

- 10mm target depth with a system EU of 0.7
- 10mm ÷ 0.7= 14.3mm average required to ensure 7/8ths of the crop receives 10mm

Emission uniformity EU

6. Interpret calculated EU value
   - EU > 0.95 — Uniformity is very good
     the system is performing very well
   - 0.95 – 0.90 — Uniformity is good
     performance better than average
   - 0.90 – 0.80 — Uniformity is fair
     performance could be improved
   - 0.80 – 0.70 — Uniformity is poor
     system should be investigated
   - EU < 0.70 — Uniformity is unacceptable
     system must be investigated

CHECK KEY PERFORMANCE INDICATORS

1. If Applied Depth or Uniformity are unacceptable
   - Repeat Operational Checks
   - Ensure system is at recommended operating pressure
   - Get professional assistance.

RUN TIME

2. Calculate Adjusted Run Time (h)
   [Target Depth ÷ EU ÷ Application Intensity].

NOTE:
Including EU ensures the Run Time applies sufficient water to adequately irrigate 7/8th plants.

3. Full system performance assessment of drip/micro irrigation systems

This section presents procedures for conducting efficient and reliable full system irrigation performance evaluations of drip/micro irrigation systems.

Procedures for planning, conducting, analysing and reporting full system performance are described. They are intended to promote efficient work practices and informative reporting that facilitates easy comparison of systems.

Procedures are presented for assessing emitter uniformity of irrigation systems applying water through non-pressure compensating and pressure compensating emitters, micro-sprayers, or mini-sprinklers, where each plant is watered by one or more outlets.

NOTE:
Complete Operational Checks (See Section 1) before commencing a system assessment.

3.1 Data collection

This schedule outlines procedures to be followed when assessing a drip/micro irrigation system under prevailing field conditions. Because test conditions will vary, key conditions must be measured and recorded to assist any comparisons between subsequent tests of the same system, or when benchmarking against other systems.

NOTE:
The purpose of the particular test may influence decisions to proceed with or abandon testing.

NOTE:
To provide system operator general operation/management information, conditions at the time of the test should be representative of those experienced in normal operation.

NOTE:
If testing is part of System Commissioning or fulfilling specific purchase contract criteria, adherence to test condition limitations is necessary.

TEST SITE

Specific locations are selected to allow overall field performance indicators to be calculated.

- Emitter discharge measurements are made in three areas representing the typical pressure variations across a lateral block to assess emitter performance and variability. Due to deposition of sediment at different flow rates these may also represent the cleanest, average and dirtiest parts of the system.
- Station by station emitter discharge tests determine station specific application intensities, uniformity and depths.
- Pressure sampling determines if the system is within the working pressure range specified by the system designer which will be based on the emitter manufacturer specifications.

SYSTEM SURVEY

System layout

1. Prepare a site map, or annotate a copy of the as built drawings of the system, recording the headworks, mainline, take-off points, sub-mains, manifolds and laterals
2. Mark location of pressure regulators, flush valves and positions where tests are to be conducted (see example Figure 3.1)

Topography and elevation

3. If the field is not level, determine elevation differences between test sites and across the station as a whole.
   - Prepare a sketch of the block showing the profiles along each of the typical laterals chosen for testing.

SYSTEM OPERATION

CAUTION:
Caution is necessary if water has been treated for any purpose, such as with acid or biocides, or contains effluent or other potential bio-hazards.

System pressure

1. Complete the test at normal operating pressure or as agreed between the client and performance assessor
   - Ensure the pressure is maintained during the test. [The operator should advise if any automated watering is scheduled that may affect the delivery pressures.]
   - Ensure pressure measurements are taken for every block, even if water is not being collected. This Is to test for consistency with the design report or commissioning reports; low valve pressures may affect non-compensated emitters more than pressure compensated systems.

Injection devices

2. If the system is designed with an injection device that is normally operative, perform the test with the injection device operating, as these components can affect delivery pressures. Otherwise ensure it is not operational for the duration of testing.

FIELD OBSERVATIONS

Crop type

1. Record the field's planting history for previous season and year
2. Note crops planted in the area under examination, and stage of growth

Crop appearance

3. Observe the crop for signs of stress or growth difference [Photographs might be useful in this respect]
4. Check for plants receiving little or no water because of system faults or blockages
5. Measure or estimate the crop ground cover proportion

Soils

6. Dig, or auger, several holes within the irrigated area
7. Determine the soil texture and depth of rooting
8. Estimate or otherwise determine soil infiltration rate and soil water holding capacity
9. Assess the level of water penetration at each site and record, taking into account recent irrigation cycles or rain fall that may have affected soils moisture levels. Note any soil features that indicate wetness, poor drainage or related properties and identify causes. [Soil moisture monitoring data may be available as a comparison too in-situ observations]
10. Assess the spread and depth of wetness under a number of drippers across the station and record

NOTE:
The behaviour of water in the dripper wetted zone is influenced by conditions existing in the soil at the time, and by previous irrigation practices. Examine the wetted zone under a number of representative emitters before the system is started, and record dimensions and approximate moisture content (see Figure 3.1).

Key dimensions include the surface wetted diameter, the wetted diameter at the widest point, the wetted diameter at about 30cm and the depth in relation to plant root zone (Figure 3.1).

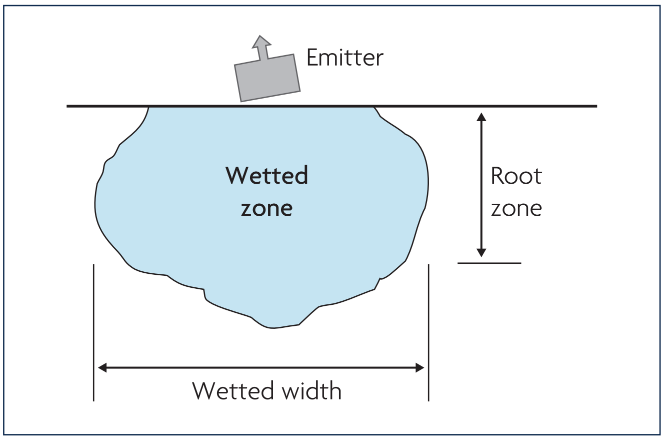

Figure 3.1. Wetting pattern under drip-irrigation outlet.

Emitters/sprinklers

11. Record details of the type of dripline, emitters or micro sprinklers fitted

NOTE:
Usually all sprinklers fitted in a micro-irrigation system should be the same. More than one type of emitter is often a sign of poorly managed system maintenance, in particular sprinkler or emitter blockage, which will likely lead to system performance failure.

Emitter spacing

12. For each station determine the emitter spacing and the number of emitters per plant
    - Calculate the average number of emitters by counting along a number of plants. The number may not be a whole number. This may also be determined by calculating this number across a whole block using total emitters [total lateral length divided by emitter spacing, divided by plant density (plants /m^2)]

Filtration

13. Identify the type(s) of filter fitted
14. Check filters [ideally noting pressure differential across the filter when running] and note nature and degree of contamination or blockage of the filter element
15. Determine when filters were checked or cleaned and the frequency of flushing

Lateral contamination

16. Randomly select at least three laterals in the station furthest from the filter
17. Inspect them for contaminants by flushing the most distant ends through a nylon filter (a stocking fitted over the open end makes a good filter to catch and inspect debris)
18. Record the time required for the water to run clear
19. Rate the amount of material (sand, clay, bacteria/algae, other) caught in the nylon sock using scale:
    1 = none
    2 = slight
    3 = medium
    4 = major

Emitter blockages

20. Conduct a visual check to determine that emitters are operating correctly (squirts and leaks around seals are obvious). Replace obvious failures before the test
21. Determine and record the cause of blockage in any emitters that are non-operational
22. Remove five emitters from distant hose ends and rate the material (sand, precipitates, bacteria/algae, insects, plastic parts, other) causing plugging using the scale:
    1 = none
    2 = slight
    3 = medium
    4 = major

NOTE:
This will require destruction of a few emitters, so ensure spares are available to repair any lines.

System leakages

23. Conduct an overall visual check (as possible) of headworks, mainline and the system to identify any leakages or other losses
24. Estimate percentage loss. [If practical measuring discharge volume from the leak and measuring pressure at the nearest testing point could be useful]

Pressure regulators

25. Identify locations of pressure regulators in the system, including automatic pressure control valves, manifold or off-take pressure regulators and pressure regulators on individual hoses
26. Identify any other points where pressure adjustments have been made, noting any presence of regulation valves in series

Unequal drainage

27. Observe the flow duration from emitters after the system is turned off. [This is particularly an issue on steep sites]
28. Determine the length of time some emitters continue to run after most have stopped
29. Assess the percentage of emitters that do this.

PRESSURE MEASUREMENT

NOTE:
Determine that pressure across the system remains within operating limits.

NOTE:
Pressure is NOT USED to determine flow rates of pressure compensating emitters

Headworks pressures

With system operating, measure:

1. Pump discharge pressure
2. Mainline pressure before and after each key component such as filters and control valves

Optionally measure:

3. Filter head loss
4. Pump control valve head loss
5. Throttled manual valve head loss

Mainline pressures

6. Measure pressure at each off-take upstream of the block control valves

NOTE:
The pressure at the start of the first lateral (see Figure 3.2 on the following page) is not a suitable substitute measurement for off-take pressure.

Distribution network pressures

NOTE:
An irrigation "station" is a management unit controlled by a single control valve. Also called Zone or Block control valves. Note under some designs blocks may be intended to run simultaneously with others to balance pump supply flow and pressures; this needs to be known before testing a block as a standalone unit to avoid invalid pressures or fluctuations.

NOTE:
Measure a minimum of three stations – or 10% of stations – depending on system size and topography.

NOTE:
In greatly undulating fields, areas with the highest and lowest elevations may represent the greatest variation. These should also be checked.

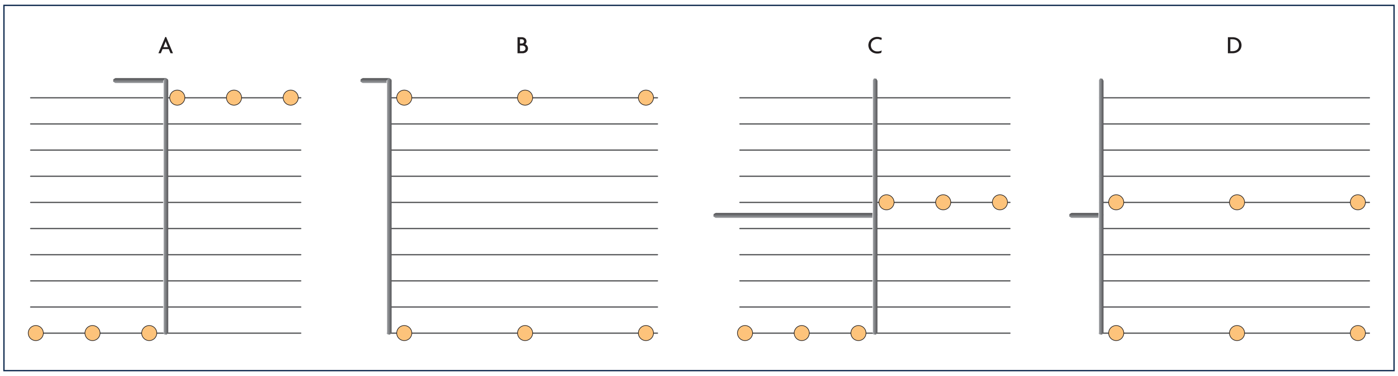

Figure 3.2. Location of positions for pressure testing

Station pressure variation

7. Measure the Pressure at the beginning, middle and end of the first and last laterals in each assessed station (see Figure 3.2 a–d)
8. Measure the Pressure at the beginning, middle and end of the first and last laterals in at least 10% of blocks If there are many blocks and high variability in system design/topography, ensure representative areas are captured

Lateral filter pressure loss

9. If there are in-line filters or strainers fitted at the beginning of laterals, randomly sample five filters from the 'dirtiest' station
10. Record the pressure in each lateral with the filter in-place, then remove the filter element and record pressure without it
11. Calculate pressure loss as the average of the five readings

FLOW MEASUREMENT

Total system flow

1. Record the system water flow rate with the system operating as normal
   - Wait until flow rates stabilise (up to 15 minutes) before taking readings
   - It may be necessary to take beginning and ending flow meter readings over a set time period to determine flow rate

Emitter discharge measurement

The purpose of these tests is to determine the Mean Emitter Discharge, Emission Uniformity and probable causes of variation (whether the result of manufacturing variability, pressure variation, in-field damage or blockages).

Dripper discharge measurement

NOTE:
The minimum collection time should be five minutes or such time as is necessary to collect at least 250mL. Measure volumes promptly especially in hot weather.

NOTE:
Ensure all discharge is collected including any from leaks around the emitter. Split rubber rings or Jiffy clips placed either side of the emitter help avoid 'dribbles' along the lateral tubing missing the collection container.

NOTE:
Drip systems with many closely spaced inbuilt emitters may be measured by collecting all discharge from a known length of lateral. Useful lengths are either 1.0 or 0.5 metres, in which case a corresponding length of spouting, or PVC pipe cut in half lengthways, is a convenient device to catch multiple flow streams.

NOTE:
Measure the Emitter Discharges at three different locations, representing the 'cleanest', 'average' and 'dirtiest' areas within the system (Figure 3.2 A–C). These locations each have a different probability of emitter clogging.

Sprinkler flow measurement

NOTE:
Higher flow sprinklers may require shorter collection times. Aim to collect for at least 1 minute or as long as possible within the volume of a 9–10 L container. Do not allow the emitter to become submerged in the collection vessel as the back pressure can affect its flow performance.

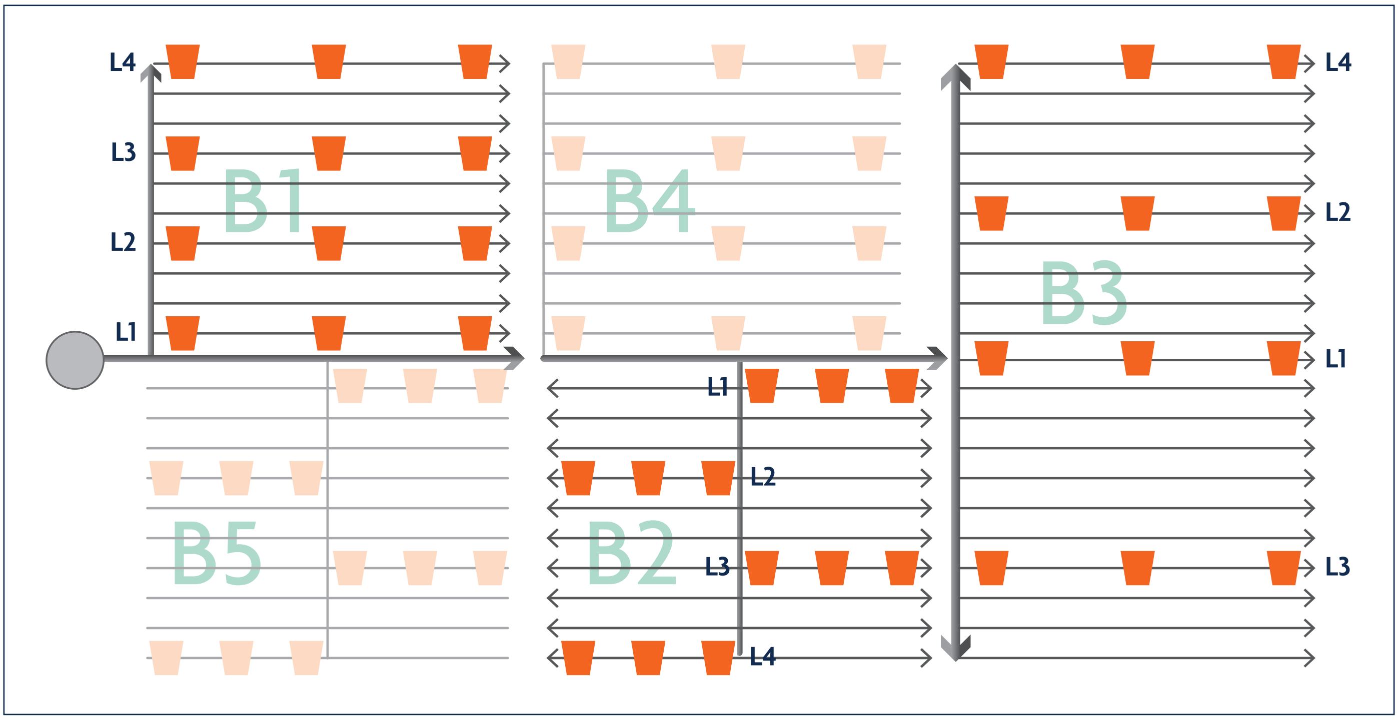

Figure 3.3. Recommended locations for emitter or sprinkler flow measurements for micro-irrigation calibration.

Cleanest area uniformity test

NOTE:

Usually the cleanest location (that least likely to have clogging) is the one hydraulically nearest to the headworks and filters (Figure 3.2 a). If a different area is known to be cleanest, select that area instead.

Average area uniformity test

NOTE:

For this and the 'clean area' tests, a sample size of 12 is sufficient assuming the system is clean and emitter variability is low.

Dirtiest area uniformity test

NOTE:

Usually the dirtiest location (most likely to have clogging) is the one hydraulically furthest from the headworks and filters (Figure 3.2 c). Often this is also a lower area. If a different area is known to be dirtiest, select that area instead. Dirt accumulation is often related to lowest pipe flow velocity where sediments settle out compared to being flushed along under higher turbulent flow rates. Low flow rates occur at the closed end of laterals and submains.

Station performance

NOTE:

An irrigation "station" is a single management unit controlled by a single control valve.

1. Measure the discharge of 12 emitters in each station (see Figure 3.2).

SYSTEM ENERGY USE

1. Obtain energy consumption (power meter readings or from pump control units displaying kWh) data for the period covered by flow measurement.

   NOTE: Energy use information is related to system pressures and volume pumped to determine energy and cost efficiency. Energy use is a key performance indicator recommended during system optimisation in the design process.

3.2 Data analysis

SIGNIFICANCE OF PRESSURE VARIATION

Micro-irrigation systems usually operate at low pressures. This means a small actual pressure variation can be large in relative terms, and can have a significant effect on flow variation.

Non-compensating outlets

Emitters and sprinklers with a simple orifice-type restriction controlling discharge rate have a predictable pressure to flow rate relationship. The flow at a given pressure can be measured in the field and compared with manufacturer's quoted values which may indicate the factor used in the flow pressure relationship.

Pressure compensating emitters

Pressure compensating emitters attempt to ensure even discharge across a range of working pressures generally by automatically adjusting the size of the orifice in response to pressure variation. This is called a dynamic response.

NOTE:
Because of the dynamic nature of pressure:flow in compensating emitters or sprinklers, measurement of the PRESSURE:FLOW RELATIONSHIP would not normally show the cause of flow variation in these systems. Flow variation in compensated emitters is more often due to manufacturing faults or maintenance requirements, i.e. the pressure compensating function simply does not work, or the emitter is blocked.

PERFORMANCE INDICATORS

Application intensity

1. Calculate *Application Intensity*

   NOTE: Application intensity under micro-irrigation is an important factor in the design process to set how long a station should run to apply a predetermined depth of irrigation.

   NOTE: Unlike other systems, low drip/micro application intensity is not generally considered as a likely system failure point based on soil infiltration rates. Some ponding may occur and thereby increase the area wetted under each emitter.

Applied depth

2. The designer will have set the *Volume Applied* to the area served to ensure that the depth of irrigation water applied is comparable with PET and water consumption for a given soil moisture holding capacity.

   NOTE: Under some drip/micro-irrigation, not all the surface area available above the plant root zone is wetted. Water movement within the soil profile is considered during the design process.

Infiltration depth

3. Calculate the *Infiltration Depth* in the wetted zone

   NOTE: The volume applied per irrigation is delivered to a fraction of the root zone available. The soil texture will influence the infiltration depth and lateral movement of the wetting front progress under the emitter lines.

4. Compare Infiltration Depth to the Root Zone Depth to determine whether excess irrigation is applied.

System uniformity

NOTE:
Capacity to control individual irrigation station watering times independently allows management to account for mean discharge variability between stations. Emitter variability within a station is not easily managed.

Emission (Emitter) uniformity (EU)
The purpose of uniformity determination is to firstly assess the evenness with which individual plants receive water, and secondly to identify those factors causing non-uniformity. It is reported as a decimal value

The procedure established below estimates an overall Field Emission Uniformity, and estimates the relative contributions to non-uniformity made by pressure, emitter manufacture, wear and tear, drainage and uneven spacing.

The use of statistical uniformity assessments enables the different contributing factors to be separated out. The determinations based on a relatively small sampling size will still be sufficiently accurate to identify areas where management can make changes to improve system performance.

In drip systems the coefficient often quoted is the emission uniformity coefficient (EU), which corresponds mathematically to the Christiansen coefficient used in sprinkler irrigation uniformity assessments.

In literature EU usually applies only to variation along a single lateral, which is not representative of a field as a whole. However, here a low quarter emission uniformity EU_{lq} is adopted to describe overall field performance.

Emission uniformity is not an efficiency measurement so is reported as a decimal value.

Emission v's distribution uniformity
Statistically derived emission uniformity (EU_{stat}) can be related to low quarter distribution uniformity (DU_{lq}), here presented as EU_{lq}, assuming a statistically normal distribution. The relationship is given by Equation 38.

Acceptability classifications for whole field uniformity determinations for each measure are presented in Table 1 (based on ASAE EP458).

Table 1 Acceptability of whole field determinations of uniformity

Rating	Emission uniformity (EU_{stat})	Distribution uniformity (DU_{lq})
Excellent	> 0.95	> 0.94
Very Good	0.94 – 0.90	0.93 – 0.87
Good	0.89 – 0.80	0.86 – 0.75
Fair	0.79 – 0.70	0.74 – 0.62
Poor	0.69 – 0.60	0.61 – 0.50
Unacceptable	< 0.60	< 0.50

Required adjustments

The flow measurements used to assess uniformity are a non-random sample, and cover only part of an irrigation event. Determination of 'global uniformity' requires that adjustments are made to account for various factors, including multiple outlets serving individual plants and unequal system drainage.

Adjustments are not generally required to account for evaporative losses from collectors as collection times are short and measurement should be rapid.

If the station contains areas with different emitters, flows or spacings, these areas need to be assessed separately.

Field emission uniformity (FEU_{lq})

1. Estimate overall field emission uniformity (FEU_{lq}) by combining contributing variable factors, using the Clemmens-Solomon statistical procedure.

   NOTE: Overall uniformity incorporates the effects of pressure variation, emitter variation, and the smoothing effect of multiple emitters supplying individual plants.

   In addition, it is adjusted for emitter defects (wear and plugging), unequal drainage after system shut-down and may be further adjusted to account for different plant or emitter spacings within the field.

Pressure emission uniformity (PEU_{lq})

2. Calculate Pressure emission uniformity (PEU_{lq}) from derived flows, using the low quarter uniformity formula.

   NOTE: The pressure emission uniformity coefficient describes a theoretical uniformity determined from pressure variation across the field, and the performance characteristics of the emitters.

   NOTE: NOT USED IN PRESSURE COMPENSATING SYSTEMS. The pressure emission uniformity coefficient is NOT USED in analysis of Pressure Compensating systems because the relationship varies across the pressure range.

   NOTE: Automated software can be controlled to avoid calculating PEU_{lq} by substituting Discharge Exponent $x = 0$ and Discharge Coefficient kd = the "manufacturer's nominal discharge" or the measured "clean area" mean emitter discharge.

Pressure derived flows

3. Calculate pressure derived flows for each of the pressure measurements taken across the field (see Figure 3.2 Distribution network pressures) using the emitter pressure flow relationship equation.

   NOTE: If the emitter discharge exponent and coefficient are not available from manufacturers' data they can be determined.

   NOTE: Pressure derived discharges are not reliable in pressure compensating systems as the relationship varies across the work pressure range.

   NOTE: If using software with calculations using the emitter pressure flow relationship negate the pressure flow relationship by substituting Discharge Exponent $x = 0$ and Discharge Coefficient kd = the "manufacturer's nominal discharge" or the measured "clean area" mean discharge.

Emitter emission uniformity (EEU_{lq})

4. Determine the emitter emission uniformity coefficient from emitter manufacturing coefficient of variation, CV_{man} and the mean emitter defect coefficient of variation, CV_{defect} determined from emitter performance tests.

   NOTE: Emitter variation is calculated to account for manufacturing variation, wear and tear and blockages, and the number of emitters per plant.

   NOTE: The statistical distribution parameter for a normal distribution, $K_{lq} = 1.27$ is used to convert to a DU_{lq} form.

Uneven drainage coefficient ($F_{drainage}$)

5. Calculate the uneven drainage coefficient

   NOTE: The uneven drainage coefficient is an estimate the impact of water draining from the system such that some plants receive greater amounts of irrigation than others. When short run times are used on undulating ground this can have a significant effect on overall system uniformity.

Uneven spacing coefficient ($F_{spacing}$)

6. Calculate the uneven spacing coefficient.

   NOTE: The uneven spacing coefficient is an estimate of non-uniformity caused by unequal plant or emitter spacings in different zones within the main field. In general, a full canopy planting should require a similar *depth* of water (but not volume per plant) regardless of the distance between plants, emitter spacing or emitter discharge rates.

OTHER UNIFORMITY FACTORS

Estimating CV_{man}

1. Calculate CV_{man}

   NOTE: In the absence of data from manufacturers or a testing facility, an estimated value of manufacturing variance can be calculated using data collected from the clean location emitter flow tests.

Table 2. Acceptable values for brand new emitter manufacture quality CV_{man}

Classification	Manufacturing Coefficient of Variation (CV_{man}) Burt & Styles	CATI (UFL)
Excellent	< 0.03	< 0.05
Average	0.03 – 0.07	0.05 – 0.10
Marginal	0.07 – 0.10	0.10 – 0.15
Very Poor	> 0.10	> 0.15

Emitter defect coefficient of variation (CV_{defect})

2. Calculate CV_{defect}

   The emitter defect coefficient of variation quantifies the contribution to non-uniformity resulting from broken, worn or blocked emitters.

   It is estimated as the difference between the coefficient of manufacturing variation (CV_{man}) and the coefficient of flow variation CV_Q in each test station 1, 3 and 4.

   NOTE: CV_{man} may have been determined in the field from the "cleanest area" flow test measurements. It is not possible to assess the individual contributions of emitter variation any more than as established above.

IMPACT OF PRESSURE VARIATION

NOTE:

Caution is required when evaluating pressure compensated systems as the pressure flow relationship is NOT CONSTANT across the pressure range.

Pressure adjusted emitter flow

1. Determine pressure adjusted flows for each emitter measured in the emitter performance tests (see clean, middle and dirty area tests). Adjust the flow of each emitter to an equivalent flow at mean field pressure.

   NOTE: DO NOT pressure adjust flows of Pressure Compensating systems.

Sources of pressure variation

2. Calculate the maximum pressure variation (kPa) between laterals, and the maximum pressure variation along laterals.

   NOTE: These should be expressed as a percentage of the total pressure variation. Non-uniformity arises from pressure variation in three identifiable places: variation between stations, along manifolds, and along laterals.

Station pressure variation

3. Identify the largest difference between inlet pressures to Stations. The pressure at the start of the first lateral may be used if not pressure test point is available at the off-take.

Manifold pressure variation

4. Identify the largest difference in Inlet Pressure between the first and last laterals on the manifolds.

Lateral pressure variation

5. Identify the largest difference between Inlet Pressure and End Pressure in the laterals.

Design uniformity (EU_{des})

6. Calculate Design uniformity (EU_{design}).

   NOTE: The design uniformity coefficient is an estimate of brand-new system uniformity determined from manufacturer's emission uniformity (EU_{man}), the number of emitters per plant, and accepted design pressure variation.

   NOTE: The equation utilises only mean low quarter and mean pressure values, so is not strictly a statistical measure. Report as a decimal.

APPLICATION CALCULATIONS

Equivalent applied depth (DZ_{app})

1. Calculate Equivalent Applied Depth (DZ_{app}).

   NOTE: The volume applied must be adjusted for the area served to ensure that the depth of irrigation water applied is comparable with PET and water consumption (mm/day). Under micro-irrigation, not all the area available for plant roots is wetted.

Infiltration depth

2. Calculate Infiltration Depth.

   NOTE: Infiltration depth under micro-irrigation is calculated from applied volumes and the wetted area per emitter (Figure 3.2).

3.3 Adjust irrigation system settings

APPLIED DEPTH

1. Compare Mean Station Applied Depths to Target Depth
    - Adjust station run time to achieve target applied depth

Adjusted run time

2. Calculate Adjusted Run Time for each Station
    - Adjusted Run Time (h) = Target Depth (mm) ÷ EU ÷ Application Intensity (mm/h)

    NOTE: Including EU ensures the Run Time applies sufficient water to adequately irrigate 7/8th plants.

Emitter uniformity

3. Identify impact of variables contributing to non-uniformity
    - Repeat Operational Checks (Section 1)
    - Adjust system components to achieve best performance
    - Ensure system is at recommended operating pressure
    - Get professional assistance.

Appendices

PART C: Micro-irrigation

Appendix 1: Micro-irrigation case study

A vineyard drip irrigation system was assessed five years after installation and found to have unexpected performance variation. The primary causes were non-specification dripline, high emitter discharge variation and high pressure variation.

SYSTEM INFORMATION

The system covered by this evaluation was five years old. It covered 79 ha with a field elevation difference of 6m.
Each vine row had one drip-line with 1.5L/h emitters at 0.4m intervals.

System history included problems with emitter blockages in areas where winery wastewater had been discharged through the drip system. The waste distribution was moved to a spray system with higher flow rates and larger nozzle diameters.

The performance evaluation assessed three different management zones. Variable factors included plant spacing, the number of emitters per plant and emitter discharge rates and wetted areas. The design allowed for zones to run for different irrigation durations and return intervals.

Table 1 System and management data

	Zone 1	Zone 2	Zone 3
Area with combination (ha)	3.32	2.70	3.52
Ground area per plant (m^2)	3.0	2.4	2.4
Drip Brand	B	A	B
Number of Emitters/plant	3.8	3.8	3.8
Nominal emitter discharge (L/h)	1.7	1.6	1.7
Wetted area diameter (m)	0.3	0.3	0.3
Crop ET at Peak ET (mm/day)	3.3	3.3	3.3
Return Interval at Peak ET (days)	1.0	1.0	1.0
Target Application Depth (mm)	3.3	3.3	3.3
Set duration at Peak ET (hours)	1.0	1.0	1.0

Figure 1. Clamping lateral to reduce in-line pressure.

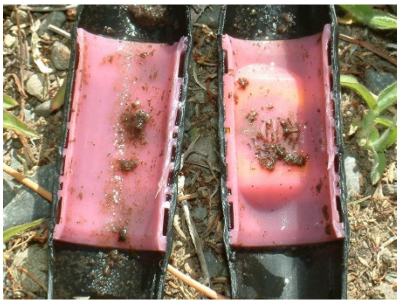

Figure 2. Dripper cut open to inspect for contaminants or other damage.

To assess performance, emitter discharge and pressure were measured in each zone. In Zone 1, 16 emitters were selected in the middle of a middle row were pressure difference was assumed minimal. After measuring discharge the pressure was reduced by about 20% by clamping the lateral (Figure 1) and the discharges re-measured. This enabled the relationship between pressure and discharge to be determined.

In Zone 2 another set of 16 emitter discharges and pressures were measured. This was selected as representing an “average” block in the vineyard.

In Zone 3 another 28 emitters were measured. This area was the area furthest from the pump and filters. Typically blockages show up sooner in such locations so system performance is anticipated to be lowest. Performance assessment protocols require a larger number of emitter measurements where variation is expected to be highest.

Pressure was tested at the beginning, middle and end of the first and last laterals in a number of blocks. These pressures were converted to equivalent discharge rates using the relationship calculated from Zone 1 data.

Additional measurements included pressure at the pump, through the headworks and at the end of the mainline (the take-off to the first irrigation block). Water meter flow and pump power consumption were also measured.

After testing, a number of emitters were removed and cut open for inspection (Figure 2).

RESULTS

Table 2 Evaluation measured data

	Zone 1	Zone 2	Zone 3
Average flow per emitter (L/hr)	2.54	1.56	2.21
Effective applied depth (mm)	3.2	2.4	3.5
Wetted area per emitter (m^2)	0.1	0.1	0.1
Percent area wetted (%)	8.8	11.0	11.0
Wetted Zone RAWC (mm equiv)	4.0	4.9	4.9
Water Meter Flow Rate (m^3/hr)	121.2	61.2	100.8
Energy consumption/hour (kWh/hr)	49.2	36.0	42.0
Energy consumption (kWh/mm/ha)	13.5	15.9	14.7

There was variation in discharge, as shown in Figure 3, but within each Zone this was acceptable. However, large variation between different Zones meant overall uniformity was poor.

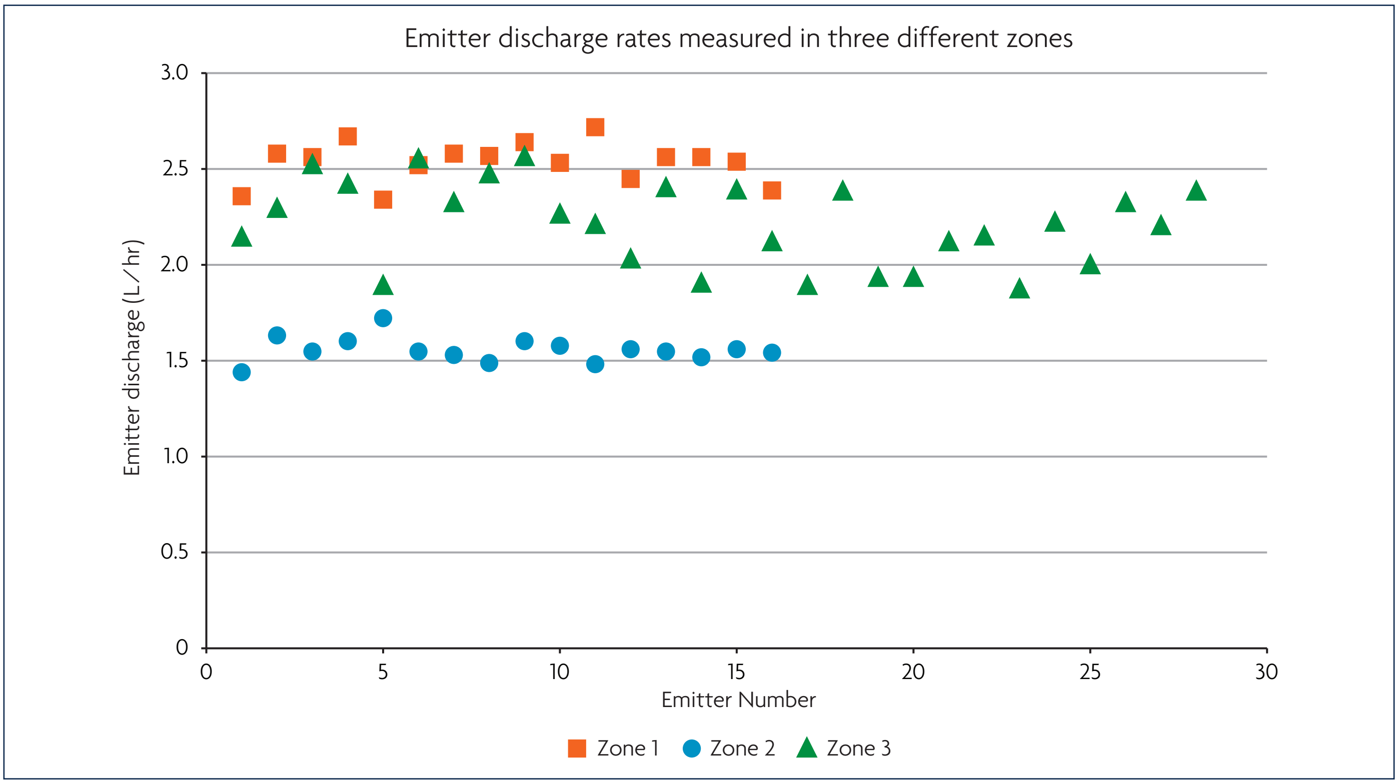

Figure 3. Emitter discharge rates measured in three different zones.

As expected and seen in Figure 3, the greatest variation was found in Zone 3.

The calculated field distribution uniformity was EU_{lq} = 0.70. This is considered poor for a micro-irrigation system.

Table 3 Interpretation of Field Emission Uniformity results: Drip-micro irrigation

Result	Perfect	Excellent	Good	Fair	Poor
EU_{field}	1.00	0.95 – 0.90	0.89 – 0.85	0.84 – 0.75	0.74 – less
ASAE 405.1		> 0.90	0.90 – 0.80	0.80 – 0.70	0.70 – 0.60

(Based on guidelines presented by Clemmens and ASAE 405.1.)

Analysing the data with the software showed the relative contribution of different variables:

The relative contributions were:

- Emitter variation = 27.4%
- Pressure variation = 34.2%
- Uneven drainage = 0.3%
- Block variations = 38.2%

Emitter variation combines manufacturing variation and damage and blockage after five years in the field. Inspection showed a build-up of algae in many emitters. Discharge rates in Zone 1 indicate this was not affecting performance.

The zone with Drip Brand A performed within 2.5% of the 1.6L/h nominal discharge per emitter and had an Emission Uniformity of 0.95 which , especially after five years operation, is excellent.

However the two zones with Drip Brand B, nominal 1.7L/h emitter discharge, performed very poorly. The measured discharge of emitters was 2.54L/h (149%) in Zone 1, and 2.21L/h (130%) in Zone 3. Their Emission Uniformity was 0.94 (excellent) and 0.86 (good).

Pressure variation results from elevation differences and friction losses between blocks, along manifolds and along laterals. Because the emitters in this vineyard were not fully pressure-compensating, pressure variation resulted in significant variation in emitter discharge rates. We measured a 10% drop off in discharge for a 20% decrease in pressure.

The causes of pressure variation include field elevation (equivalent to 60kPa), mainline losses and some excessively long rows. This is illustrated in Figure 4.

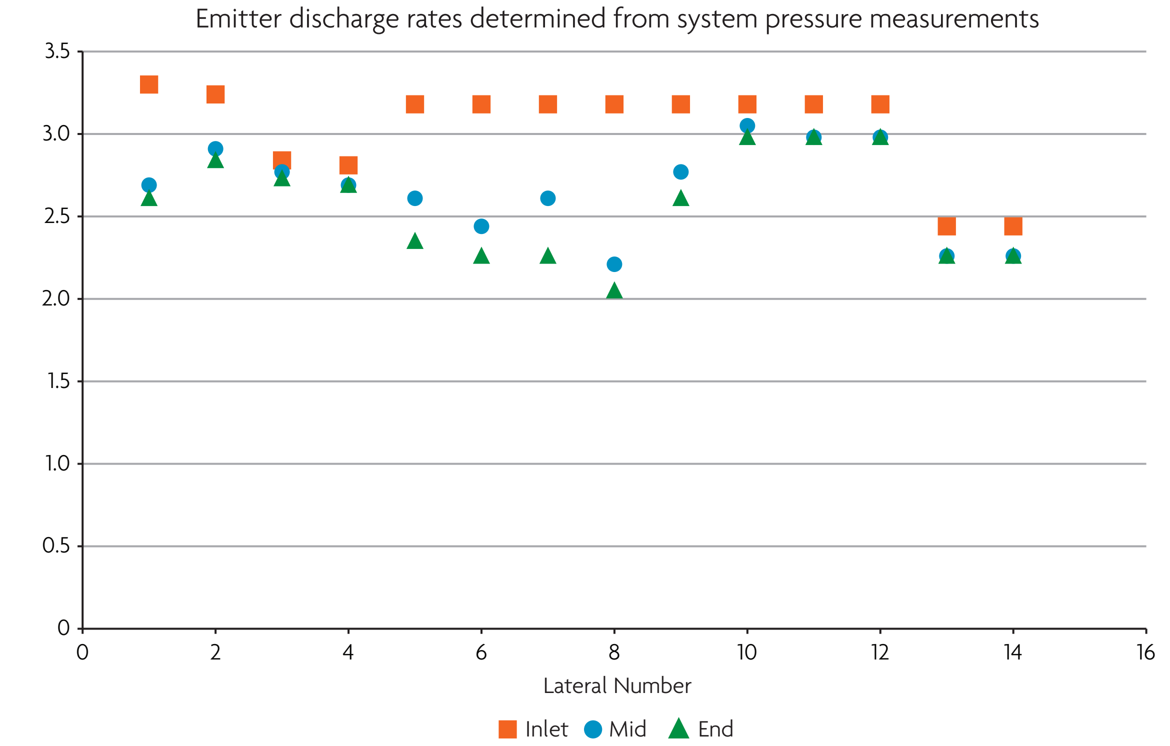

Figure 4. Emitter Discharge Rates determined from pressure measurements in driplines

Each pair of laterals corresponds to the first and last laterals in a block. Many laterals, including lateral 1, show a large drop between the inlets discharge and the mid and end lateral discharges. This is indicative of lateral pipe that is too small bore or excessively long for the amount of water being piped. The beginning of the lateral has all the water entering it, and friction losses are at their maximum. Further along the lateral, flow rates reduce as increasingly more water has been emitted.

Laterals 3 & 4, and 13 & 14 are blocks where the inlet pressure is too low. There is little pressure loss along the laterals, but discharge is below target across the whole block.

Uneven drainage assesses the effect of areas that fill first and keep running longest after shut down. This is more severe with frequent, short duration irrigation events.

Block variations relate to different plant or emitter spacings, or to run times of different blocks. We identified variation in plant spacing and flow rates, but block run times were the same. Plants that occupy greater areas use relatively more water and require more irrigation. This must be reflected in different emitter spacing or run time. This performance assessment found block variation accounted for 38% of the non-uniformity of the irrigation system.

RECOMMENDATIONS

Maintenance

- Hose flushing:
  Hoses should be flushed for several minutes at least once a month. This cleans out the sediment which settles out in the last half of the hoses, and which can cause serious plugging problems if it accumulates. Some growers install flushing hose end caps which automatically flush during system start-up and shut-down. These require careful design as they can fail to close if insufficient pressure is generated.
- Injection to prevent plugging:
  While the emitters appeared to be discharging correctly, the presence of obvious algal build-up is concerning. Chlorine is typically used to inhibit organic plugging of drip systems. Recommended dosages vary from 0.5 to 10 ppm. Timing of injections usually range from continuous injection to once per week. The dosage and timing will depend upon the water quality. Chlorine activity is enhanced by reducing the water pH (ie, making the water more acid).
  Plugging problems due to bacteria or algae often do not show up the first year or two of drip system operation, and then may reach suddenly catastrophic proportions unless chemicals are injected on a routine basis.
- Pressure control:
  Pressure variation between blocks may be caused by incorrectly set off-take valves or pressure regulating valves if fitted. These should be checked to allow the same pressure in each block.

Management

The block variation can be managed by adjusting Zone run-times.

- Differing emitter discharge rates:
  Blocks with Brand B dripline should be run for shorter durations to account for higher than specified discharge rates. Note however, that at high discharge there is high pipe friction so longer rows have lower discharges from emitters towards the lateral end. Replacing the dripline is necessary to fully correct this problem.
- Larger plants:
  Blocks with larger plants require more water so should receive longer irrigations. However the soil has very limited water holding capacity so care is needed to ensure the extra water does not drain past the effective rootzone to waste. Shorter durations at closer intervals may be needed.