DairyNZ/EngineeringNZ

Practice Note 21: Farm Dairy Effluent Ponds

APPENDIX B: POND SEEPAGE TESTING

(August 2024)

(WSP Project No: 3-39662.00)

Contents

1 Preface

This Appendix replaces in its entirety Section 8.6 *of IPENZ Practice Note 21 (PN21): Part 1: Farm Dairy Effluent Ponds* (Version 3, August 2017) previously prepared and published by project partners DairyNZ and EngineeringNZ.

PN21: Appendix B is not intended to be a separate standalone document but to be read in conjunction with the supporting guidance that PN21 provides.

The need for its development as a separately released document has been driven by a combination of factors, including:

- The need for a standard NZ test method for Pond Drop Test (PDT) testing, and this has allowed a range of different PDT methods and test report contents to be developed and offered to pond owners.
- The quality of PDT testing and the accuracy of equipment used across NZ is highly variable.
- While the PDT equipment and methodology offered by testing suppliers generally meets the previous PN21 Part 1: section 8.6.2 and is appropriate for identification of gross seepage, it is no longer suitable to demonstrate regional council pond seepage compliance.
- For a consistent compliance regime, a nationally recognised basis on which to determine whether effluent ponds comply with seepage rate limits included in their resource consent conditions and regional rules is needed.

Appendix B is intended to provide good practice guidelines for professional engineers and other technical specialists involved in the testing and measurement of seepage from effluent ponds. It is also intended to be a reference guide to RCs as well as service providers to the Farm Dairy Effluent (FDE) industry.

This document will be further reviewed, amended, and incorporated into an updated version of the current PN21 when funding and industry support is available.

2 Introduction

All ponds, regardless of their liner types, are subject to potential damage from various causes, such as from unsuitable design, poor installation, lack of maintenance, or inappropriate operation. Ongoing inspection and testing will identify issues affecting the pond's primary purpose of temporarily storing liquid effluent without incurring an unacceptable rate of seepage or leakage loss.

The provisions of App B are limited to geomembrane, clay, or concrete lined ponds, and specifically excludes bladder or other types of tanks with flexible walls

Ponds should be appropriately tested for seepage regularly through its service life, to confirm its fitness for purpose as well as demonstrating conformance to applicable environmental regulations and resource consents.

The words seepage and leakage are often used interchangeably but for this document the word seepage is used.

Pond seepage through pond lining materials can be indicated by various assessment approaches, including those listed below, by increasing accuracy:

a) Visual Inspection of the condition of the lining material and observing typical indicator features if seepage was to be occurring around the pond.

b) Pond Level Monitoring (PLM) of changes in pond surface level by simple measurement means while restricting any pond inflows or outflows during the monitoring period.

c) Leak Detection Testing (LDT) by measuring and analysing the discharged effluent volume by means of a Leak Detection System (LDS) that captures any seepage that may be leaking down through the lined surface area.

d) Pond Drop Test (PDT) is an extremely accurate test by a specialist PDT test supplier ('supplier') requiring development of a precision equipment system that measures continuous changes in pond level.

Note that test options b) and c) will only provide an indication of whether excessive leakage may be present and are not an alternative or replacement for d) as specified by RCs for compliance purposes.

A high precision PDT system, together with the methodology as provided in this Appendix, is necessary to achieve the testing accuracies necessary for pond owners to demonstrate liner seepage compliance.

3 New Ponds

For all new, or highly modified ponds, 'good practice' as set out in PN21 must be applied in their design and construction. This is best established through the advice and direct involvement of a suitably experienced Chartered Professional Engineer (CPEng) from the pond's development through to its completion.

Following the commissioning of the pond, the pond owner should request a signed *Final Completion Certificate* from a CPEng, with competence in the relevant engineering practice area, to confirm that the pond as constructed conforms with the issued design drawings and specifications, verified as fully functioning, and meets the following acceptance criteria.

Final Completion Certificate

Acceptance Criteria:

(a) Both the design and construction of the effluent pond meets the good practice guidance provided in the DairyNZ/Engineering NZ Practice Note 21 (latest version); *and*

(b) where a geomembrane liner is installed, a warranty certificate of at least 10 years on the liner material product and 5 years on its installation has been issued by the liner supplier and installer respectively; *and*

(c) within 6-months of the pond's construction completion, that:

i) an initial PDT has been completed and the ponds measured seepage rate complies with the local regional council requirements; *or,*

ii) the LDS discharge volume and rate has been measured and analysed and is deemed by equivalence calculation by the Engineer to be less than the local regional council PDT maximum seepage rate, (typically <1 mm/day).

Obtaining this certificate has the advantage that it could qualify the pond for a longer PDT retest frequency.

4 Pond Seepage Assessment

4.1 Visual Inspections

In addition to PLM and LDT testing, the landowner should monitor and inspect their Farm Dairy Effluent (FDE) ponds, including its connecting infrastructure, at least on an annual basis and record their observations in their asset management system:

- Pond level – is there evidence of overtopping? Freeboard should be kept >0.6m to allow for unexpected filling. Consider if the pond level is unexpectedly low, or high, which may indicate a leak concern. Could there be groundwater ingress raising the water level?
- Geomembrane (synthetic) liners – no liner tugging or tearing is present, no visible damage to the liner including subsidence behind or underneath the liner, and gas is not accumulating under the liner. As the liner under aerators and pump intakes can be subject to greater wear and tear, these should be areas of special visual attention.

  Also note that geomembrane liners can be subject to harsh Ultraviolet (UV) conditions in New Zealand, and some can deteriorate more quickly than the warranties often offered by international manufacturers.
- Pond Bunding – are there damp areas on the outer slopes of the pond bund. Also look for, shrubs or trees with roots that could be penetrating the liner, or on the anchor trench which provides support to a geomembrane liner.
- Clay liners – no excessive erosion, drying, cracking, or visible damage to the lining.
- Pipework – check for leaks or damage to pipes, particularly where they penetrate bunding, lined walls or structures.

4.2 Leak Detection Systems

A well designed and installed Leak Detection System (LDS) will provide an indication if excessive seepage through the liner is present. All new ponds should incorporate an easily monitored LDS that can itself be periodically tested to confirm it is continuing to operate as designed. PN21 Part 1 Section 5.10.1 provides further guidance.

This approach involves carefully collecting a measured volume of outflow over a timed period. To maximise its value pond owners should consider the following matters:

- Does the system cover and capture the whole underside of an installed liner in the pond?
- Can the effectiveness of the whole LDS system be tested periodically to confirm it is continuing to operate without blockages and function as designed?
- How is the LDS outflow liquid to be collected, measured, and analysed, and determined whether it is effluent, or groundwater, or a mix of both?
- What measured maximum leakage rate should be of concern, this being based on the ponds wetted surface area and volume, and with comparison to the calculated equivalent allowable PDT seepage rate.

4.3 Pond Level Monitoring (PLM)

A simple PLM system can be undertaken by placing a partially submerged graduated stainless-steel rule fixed to a driven solid steel post at an accessible location at the ponds edge. Alternatively, where the pond liner is at risk of being damaged by the post, another fixing arrangement would need to be explored, such as by attachment to a permanent stable structure on the pond's perimeter. For accuracy, a rule, or other measurement means with graduations of 0.5mm or better should be selected.

Preparations for the test include the pond being largely free of floating solids, at least 75% full, and all inflow sources and outflow locations blocked off. The weather forecast should be checked to confirm that a settled period of mild weather without rainfall, or high winds, or freezing temperatures can be expected. Personal safety measures while undertaking readings should also be considered.

The test involves recording an initial reading (in mm) on the rule at the top of the formed liquid meniscus as well as the day and time of the reading. Some means of magnification onto the rule will assist in reading accuracy. A further reading is taken 2 to 3 days later, the level difference calculated, and the average seepage rate in mm/day determined.

Other low-cost measurement systems that monitor changes in water level, with or without environmental corrections applied, are another alternative.

$$Seepage\ Rate\ \left(\frac{mm}{day}\right) = \frac{Reading\ (final) - Reading\ (initial)}{Test\ Hours}\ x\ \frac{24}{1}$$

While the test result from such a PLM system will not be suitable for consent compliance purposes, it will provide an indication to the pond owner whether gross pond leakage (typically >5 mm/day) is occurring and if an earlier than expected PDT is warranted.

5 Pond Drop Test (PDT)

5.1 Introduction

The PDT test is the most accurate means available to confirm a pond's seepage rate is still within acceptable limits. Such accuracy is essential to verify that the rate is satisfactory for purposes such as, sale and purchase agreements or for resource consent compliance.

Because the permeability (or flow) rate through the 'wetted surface' contact area of a ponds liner cannot be directly assessed, the PDT test which measures the change in the ponds surface water level over time has been developed as a proxy measure. The internationally accepted upper limit of the permeability (also referred to as hydraulic conductivity) of FDE pond lining material is 1×10^{-9} m/s, which is equivalent to a PDT seepage loss of -0.8 mm/day, or if rounded up, -1.0 mm/day. A day is a 24-hour day.

To achieve the necessary accuracy, costly precision measurement technology systems able to measure to fractions of a millimetre are essential. Environmental influences such as rainfall and evaporation must be considered, and relevant corrections made. To successfully operate this equipment, personnel with the necessary instrumentation and related technical skills are essential. Furthermore, detailed spreadsheets or specific software developed for the test analyst are necessary to examine the data and identify any anomalous readings or sections of data that should be rejected.

The test supplier will prepare a detailed test report along with an accompanying CPEng signed test certificate which the pond owner can forward, if required, to other parties including RCs for resource consent purposes.

5.2 Pond Preparation

Key to obtaining reliable test results is the preparation of the pond prior to PDT testing commencement and will necessarily include the following tasks:

5.2.1 Program the Testing:

- Forward planning is the key.

PDT testing is best programmed for a time of the year that fits in well with the farm's cyclical effluent activities. At the time of testing the pond needs to be near full and for the weather to be preferably cooler and more settled. Early engagement with the PDT test supplier is recommended to book in suitable dates well ahead of time.

5.2.2 Cleanout the pond:

- Clean out floating weeds, crust, heavy scum, and excessive foam.
- Remove excess sludge deposited and built up on the pond base.
- Remove solids from stone/silt traps and connecting channels.

Floating crust or vegetation and thick scum can lead to fouled sensors, and pond level data errors. It can also affect evaporation rates and the corrections subsequently applied. It may be necessary to postpone PDT testing until a pond has been sufficiently cleaned out.

Ponds also need to be regularly cleaned out to retain their designed maximum storage capacity. A deep sludge layer can also conceal the true seepage rate of a ponds liner.

5.2.3 *Fill up the pond:*

- At test commencement a pond must be a minimum of 75% full, and preferably fuller, with the surface level at least 200 mm below the outlet minimum level. The designed outlet point may be an outflow pipe, channel, spillway, or perimeter bank.

The 75% minimum prerequisite allows the pond's wetted surface area being tested to be maximised. It also provides some available pond capacity for unexpected inflows, such as from rainfall into the pond's catchment over the test period.

The fuller the pond, the less the need to climb done the slope to set up or adjust test equipment in contact with its effluent.

5.2.4 *Do not stir the pond:*

- Do not stir the pond in the 3-day period prior to test commencement.

Stirring the pond does not prevent a crust reforming and can contribute to an inconclusive or failed PDT result.

5.2.5 *Identify preferred test site:*

The following site characteristics are preferred as the most suitable location to site the test equipment on the pond's perimeter,

- Being able to park a vehicle as close as possible to the site to ease transportation of equipment.
- Avoidance of fences needing to be crossed.
- Easy site accessibility, including not having to walk through shrubs, trees, thick long grass, and boggy areas.
- Flatter, easily negotiable slopes, on good stable ground.
- A cleared vegetation site area on which equipment may be easily and safely placed.
- Close to a pond access ladder (if fitted) or other accessible permanent infrastructure.

5.2.6 *Isolate the pond to be tested:*

- Effluent inflows should be diverted into temporary or other storage where this is available. All liquid inflows into the pond for the duration of the test, such as from the dairy shed, feed pads, stormwater, or surface drainage, must be prevented. All pipes to or from the pond must be firmly capped or otherwise securely blocked off.
- Weeping walls flowing into the pond must be completely cleaned out or blocked off from the pond being assessed. Depending on its construction and bed level, a weeping wall may be able to become part of the pond for the test duration such that its bed is also included in the PDT test.
- Check for leaks where any liquids could be unintentionally flowing into the pond. Sumps, hoses, taps, green wash, and stormwater diversion systems must be checked for possible leakage. Look for flow along the outside of buried pipes.
- While not preferred, inflow from dairy shed washdown may be able to be accepted, but provided the PDT installer is informed of the times and frequencies of these milkings so that these periods can be removed from the data analysis. Accordingly, to ensure minimum data set length is still available for the analysis, the overall duration of the site testing should be extended.

Note that any unaccountable inflows or outflows during the test will invalidate the test data while these persist.

If the pond being tested is part of a two-pond system, then both ponds must be hydraulically isolated from each other. This may involve earthworks filling with compaction to temporarily seal the opening between. The alternative is for them to be tested as one pond by digging a channel at least 1m wide and 1m deep between to provide a level gradient with unrestricted flow in both directions.

If they are solely connected by a pipe, it must be completely blocked or capped off.

5.3 Field Testing

5.3.1 Safety

Working near, in, on, or over effluent ponds is a hazardous activity with high risks and needs to be recognised as such.

Prior to undertaking work around effluent ponds, personnel must identify, assess, and control hazards associated with the work. A task-specific risk assessment should be prepared and reviewed by a competent person, and hazards and control measures recorded. The risk assessment must cover all potential risks that may be applicable to the work.

The site conditions and risks posed by working around effluent ponds can and do change. It may be necessary to re-assess the potential hazards and control measures on site prior to commencing work and as work progresses. Where conditions vary significantly from those considered in planning, on-site personnel must determine whether it is safe to proceed, if the risk assessment and control measures need amending to undertake the activity safely, or if the activity must be stopped and re-scheduled.

It is highly recommended that while on site the following measures be adopted:

- At least two people must be in sight of each other (this could be the PDT operator and a farm employee).
- At least one person must be able to raise the alarm if an emergency occurs.
- Communication devices be available that are waterproof and suitable for the location (i.e. satellite-based in remote locations).
- PPE and rescue equipment be available that has been tested and is in good working order.
- Wear PPE and clothing that is appropriate for the work tasks being undertaken. Depending on the site this may need to include a safety harness, life jacket, life rings, and employing ladders, or safety ropes.

To further reduce operator risk, careful thought should also be given to the design and operation of the test equipment system employed in the field. This could include developing specific aids, extension arms and alternative methods for firmly securing equipment to the ground surface, and to reduce working directly on steeper slopes or contact with effluent.

5.4 PDT Testing Frequency Flowchart

To reflect the risk of excessive seepage being detected, the following *PDT Testing Frequency Flowchart for Effluent Ponds* has been developed. This chart reflects risk factors that can impact the ongoing performance of various types of pond construction materials and their liners. The higher the seepage risk, the more frequent the retesting frequency specified.

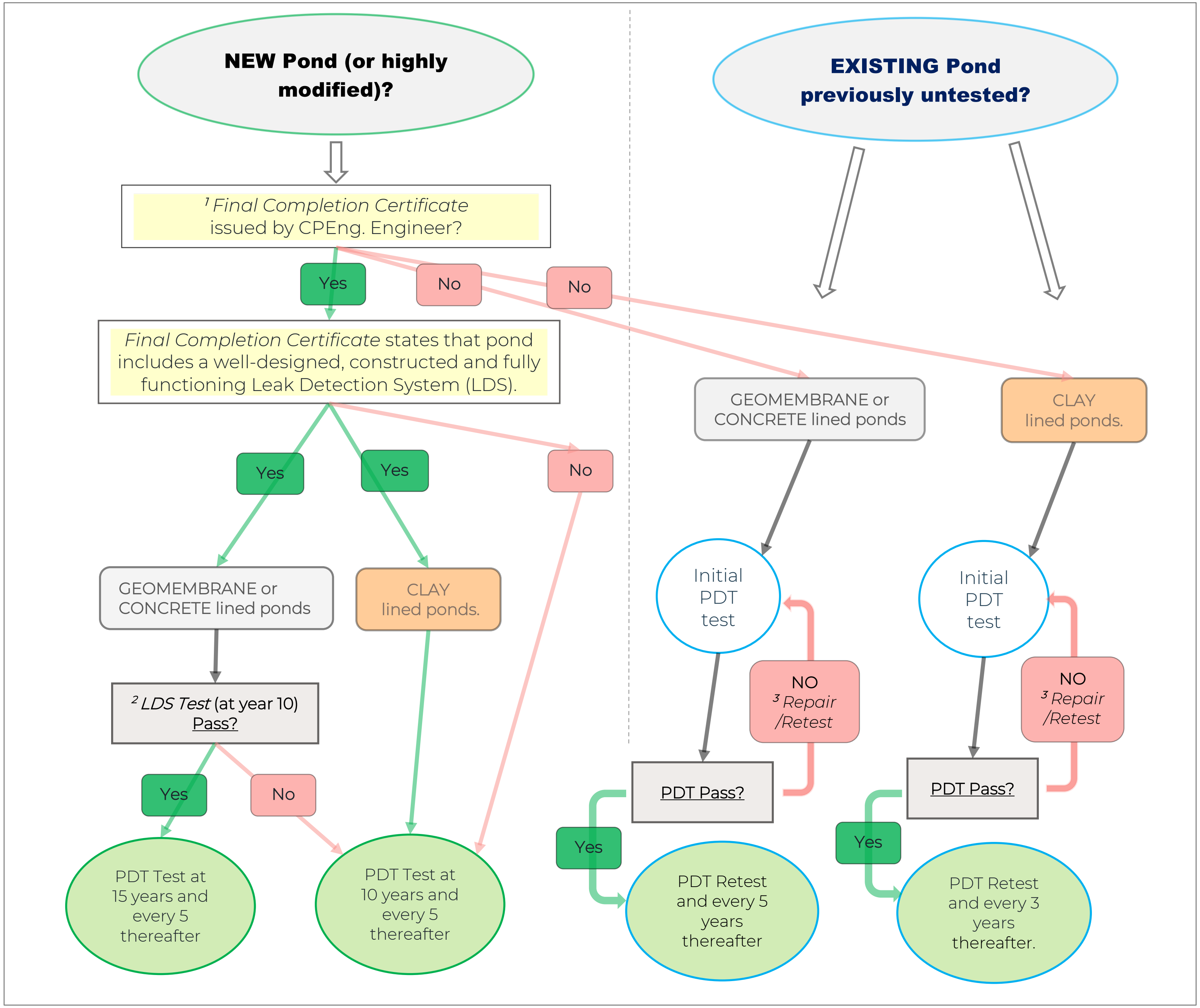

Figure 1:

PDT Testing Frequency Flowchart for Effluent Ponds

Notes:

1. For geomembrane lined 'New Ponds', only, that were Engineer designed, constructed and completed between 2014 and 2024 for which a *Final Completion Certificate* was not requested, a PDT test at 10 years and every 5 years thereafter is applicable.
2. *LDS Test* - Sampling, testing, and the issuing of a test report from an accredited testing laboratory or agency, or from a CPEng, confirming, by equivalence calculation, that the pond's seepage rate is less than the maximum acceptable PDT rate.
3. *Repair/Retest* to be as soon as reasonably practicable after an unacceptable PDT seepage rate result being advised to the pond owner.

For operational ponds, a PDT retest and pass required within 6 months following any significant repair, mechanical clean out, or obtrusive works on the pond.

5.5 Test Equipment

5.5.1 Accuracy

To provide extremely accurate measurement changes in pond depth level, a continuously recording sensor with the associated data logger unit taking readings at 1-minute intervals or less is essential. Written evidence from the manufacturer that the combined accuracy for these specific items is better than ± 0.2 mm is recommended.

5.5.2 Uncertainty of Error

Measurement of pond depth change to the necessary accuracy expected by regulatory authorities, and with confidence, is difficult to achieve without some uncertainty being attached to the seepage rate result reported. Therefore, seepage test results need to also be accompanied by an Expanded Uncertainty of Error value assessment.

The 'Error' refers to the specific unknowable difference between the measured value and the unknowable true value, while 'Uncertainty' refers to the range of possible values of the error of the measurement. An error can be positive or negative since the measured value can be more or less than the true value.

To confirm the accuracy of the full PDT measurement system, it must be assessed by a recognised metrology laboratory and confirmed by their report that it has an Expanded Uncertainty of Error of less than ± 1.0 mm.

(Expanded Uncertainty of Error is based on the standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.)

Evaluation by the metrology supplier should include both a laboratory and field-testing component in assessing the total of the individual identified measurement system errors.

The Expanded Uncertainty of Error analysis is to include, but not limited to, all identifiable uncertainty components in the PDT measurement system, including both pond and evaporation sensors (including calibration uncertainty, non-linearity, hysteresis, and resolution), temperature shifts, rigidity of supporting structures including thermal expansion effects, wind effects, and reading repeatability. Note that the Expanded Uncertainty of Error is expressed as the sum of all the relevant uncertainties from all the error contributing components, and with a 95% confidence.

The Uncertainty of Error can be estimated by using the methods of 'A Beginner's Guide to Uncertainty of Measurement' by Stephanie Bell which is based on the United Kingdom Accreditation (UKAS) Publication M 3003, 'The Expression of Uncertainty and Confidence in Measurement', and the Publication EA-4/02 of the European co-operation for Accreditation (EA), 'Expression of the Uncertainty in Measurement and Calibration.

Suppliers of metrology services in NZ include:

WSP Research (Petone) https://www.wsp.com/en-nz/hubs/research
MetCal (Hamilton) https://metcal.co.nz/

Where a supplier operates more than one of the same PDT measurement system units and they are comprised of the same components, then a single metrology laboratory assessment report on a representative unit would suffice. A reassessment should be undertaken every 5 years, or when one of the systems components is replaced with a non-identical or alternative part.

To support their PDT test report, the PDT supplier must be able to produce on request a copy of this report to their clients, or others taking reliance on those reports.

5.5.3 Test Duration

A minimum continuous test measurement duration of 50 hours is required, but that should be extended for longer if unsuitable weather conditions are known to have occurred, or unavoidable regular but limited periodic inflows/outflows are occurring during the test period.

The longer the test duration, the more accurate the calculated average daily seepage rate that can be expected.

However, there is a situation where the preferred 50-hour test duration may be able to be reduced. This is where data is being continuously telemetered or manually downloaded from site to the analyst, but only if they can confirm that at least 35 hours of ‘good’ telemetered data has been received, and the graphed data is indicating a clear and consistent seepage rate pattern over this period before the test can be terminated.

5.6 Data Corrections

Relevant corrections must be applied to the selected sections of data during the post testing analysis. Rainfall and evaporation will have a significant impact, but there may be other environmental factors depending on the equipment system used for which corrections must be made.

5.6.1 Rainfall

To identify times that any rainfall starts and stops, a continuously recording automatic data logging rainfall gauge must be installed at the test site. It needs to incorporate a tipping bucket arrangement and record the start and end time for each continuous rainfall aggregation of 0.2 mm or more.

All test periods during which rainfall has been recorded are to be <u>excluded</u> from the analysis. The reasoning for this is that the recorded rainfall often does not always exactly align with the actual pond depth increase because the pond surface area is typically smaller than the pond catchment area. Further, there can be surface channels and other inflow sources which will direct rainfall into the pond during rainfall periods that will not be reflected in the rain gauge reading.

The accuracy of the PDT test is dependent on limiting error sources to fractions of a millimetre. Removing rain affected data sections eliminates this error source.

5.6.2 Evaporation

Pond depth data must be corrected for the evaporation on the pond during the test. This is best achieved by using a floating evaporation pan of not less than 800mm in diameter and 450mm high (including freeboard).

The floating pan must incorporate a depth measuring sensor, similar in accuracy to the pond level sensor, with continuously recorded readings being taken at 1 minute, or less, intervals.

International research literature confirms that floating evaporation pans more closely simulate actual pond evaporation, and with less variability than alternative land-based pan systems. Therefore, to provide the necessary test accuracy, land-based pans should not be used.

However, evaporation rates in floating pans can still be influenced slightly by the heat transfer characteristics of the pan material and pan rim height affecting evaporative sun and wind action across the pan's liquid surface.

While pans manufactured from metals have the higher thermal conductivities, lighter weight High Density Polyethylene (HDPE) pans have the highest heat transfer coefficients among the plastics and can be successfully used.

The measured evaporation from the floating pan needs to be corrected to an open water condition by applying an evaporation coefficient during data analysis. Based on research, this will likely sit between 0.85 and 1.00 depending on the specific conditions experienced (e.g. nearer to 0.85 for a high evaporation test scenario and closer to 1.00 for a minimal evaporation test.) An average coefficient of 0.90 can generally be adopted.

PDT suppliers should consider undertaking their own research to determine an appropriate coefficient for their specific floating evaporation pan system.

5.7 Data Analysis

There are a variety of uncontrollable factors that can affect the accuracy and validity of the recorded data, and awareness of them by the analyst is essential. These factors will include:

5.7.1 Groundwater

If the surrounding ground water level (GWL) is above the base of the pond, then it can flow back through the pond's liner and into the pond. This will be evidenced by the ponds surface level appearing to rise throughout the test. GWL can also rise and fall as the result of localised rainfall, flooding, pumping and irrigation.

Rather than a liner condition issue, a gain (or loss) in the pond level may be indicative of a larger groundwater or seepage issue across the pond site.

5.7.2 Diurnal Effects

It should be noted that there can be distinct differences between daytime and nighttime temperatures leading to diurnal effects. Pond levels and evaporation rates can appear to cyclically go up and down and it may be appropriate to analyse the data as 24-hour sections to reduce these effects.

There is also the argument that there is generally less evaporation during the hours of darkness, due to lower temperatures and the absence of the sun's evaporative effects, and so evaporation adjustments therefore can be avoided. However, it avoids the fact that wind also occurs at night and will create some evaporation and still needs to be recorded and analysed.

Irrespective of these viewpoints, to achieve the accuracy required of this precision test, every possible measurable correction to the data must be applied to achieve the accuracy provided for in this test method.

5.7.3 Wind Speed

Wind can create surface waves affecting recorded levels on both the pond and evaporation pan surfaces. Further, wind against the side of the pan can cause it to rock, or being overtopped, leading to unstable or incorrect readings.

Where the average wind speed exceeds 25 km/h over a 10 min interval then these data sections should generally be excluded from the analysis. However, average wind speeds of up to 30 km/h over a 10 min interval might be acceptable if the close analysis of the data section shows no impact on the quality of the data.

5.7.4 Anomalous Data

Following field testing, all recorded data needs to be downloaded into a spreadsheet or specifically developed software, where it can be closely analysed. Graphing the data and the visual assessment of it must be carefully undertaken to identify any sections of anomalous data which must be removed from the analysis. Sources of such data can include the impacts of wildlife, inlet or outlet pipes on automatic timers, disused pipe networks, as well as groundwater, catchment, and surface inflows.

5.8 Test Report

5.8.1 Result Reporting

Test reports are to express the seepage (as a negative number) in the form of:

$$\mathbf{Seepage} = \boldsymbol{RESULT}(\mathbf{mm}) \pm \mathbf{1.0}(\mathbf{mm}) \text{ millimetres per day}$$

[Where: $\boldsymbol{RESULT}$ is determined from the PDT test, but additionally assigned an Expanded Uncertainty of Error of ±1.0 mm; seepage is expressed as a negative number.]

5.8.2 Seepage Pass/Fail Criterion

It is expected that RCs will generally be accepting of maximum seepage limits of:

$$\mathbf{Seepage} \leq -\mathbf{1.0} \pm \mathbf{1.0} \text{ mm/day}$$
$$(Includes\ an\ Expanded\ Uncertainty\ of\ Error\ of \pm 1.0\ mm;\ seepage\ is\ expressed\ as\ negative)$$

Or, alternatively expressed as being within the following seepage limits:

$$+\mathbf{1.0} \leq \mathbf{Seepage} \geq -\mathbf{2.0} \text{ mm/day}$$
$$(Includes\ an\ Expanded\ Uncertainty\ of\ Error\ of \pm 1.0\ mm;\ seepage\ is\ expressed\ as\ negative)$$

It is up to each RC to decide at what maximum pond test seepage rate they might want to not accept or take follow up actions on. Other RCs may only consider following up with the landowner if they deem the leakage to be excessive, or there are other contributing issues. Therefore, reports should avoid stating that the pond passes or fails as this is up to the individual RC to ultimately determine.

Another consideration for RCs in the setting of any pass/fail criterion will be whether the depth of the pond is a relevant factor. Deeper ponds have a higher hydraulic head than shallower ones and will therefore have a higher seepage rate for the same liner condition. PN21 Part 2 Section 2.3 explores this matter further.

5.8.3 Report Information

The test report should contain all information that would assist potential readers to understand how the reported seepage result was obtained, and supported by other relevant site details:

- Pond owner, name, and address
- Pond name and location
- Estimated pond dimensions
- Condition of pond
- Test method details
- Test date(s), start/end times
- Weather details
- Test periods, both included and excluded from the analysis
- Change in pond level, including corrections applied
- Seepage Rate for the effective monitoring period
- Seepage Rate (mm/day)
- Factors that may have affected results
- Graph of level changes
- Aerial plan, and photographs
- Name and dated signature of (i) the analyst who prepared the report, and (ii) the CPEng reviewer.

- While an engineering inspection of the pond site is outside of the scope of the PDT test, any observable concerns by the PDT field technician that may contribute to leakage should be recorded as observations on the PDT report. Such observations include trees on pond embankments, high water table relative to pond level, evidence of slumping/subsidence, or other issues identified.
- All prepared PDT test reports to be reviewed with the report signed off by a Chartered Professional Engineer (CPEng) with competence in a relevant practice area.

5.8.4 Test Limitations

The test report should include a limitations statement that advises the pond owner of any limitations from the PDT supplier. Examples of the types of limitations may include the following, but suppliers could add their own as well:

- Where the Client, or their staff, provides information to the ('supplier'), or where we have obtained and/or relied upon information provided from another party, we have not verified this information. The ('supplier') assumes no responsibility for any inaccuracies in, or omissions to, that information.

- No inspections, other than any noted within, have been undertaken in support of the conclusions of this report.
- Groundwater and surface water inflows through the ponds wetted surface area from lower than surface level was assumed to be negligible during the test.
- Analysis accuracy is dependent on the Client having prepared their pond and operated it during the test as advised in pre-visit instructions.
- Dissimilar measured evaporation rates between adjacent ponds and test equipment locations at similar times may be due to factors such as differences in salinity, turbidity, surface sludge content, water depth, and ambient atmospheric conditions experienced.
- Reliance should not be placed on the absolute values derived from the analysis. All data collected, and its analysis, is subject to error and variability within the limitations of the test equipment and method.
- A change in circumstances, facts, or information after this report has been prepared may affect the adequacy or accuracy of its conclusions. The test supplier is not responsible because of any such changes.

5.8.5 PDT Certificate

A separate accompanying PDT Certificate should also be issued to the Client along with the test report. This certificate should contain as a minimum the following related test information:

- Pond owner name and address
- Pond location/name
- Date of testing
- Seepage rate (i.e. unaccountable change in pond level) in mm/day
- CPEng name, registration number, and dated signature
- Any other information the Client wishes to be added to the PDT Certificate.

On approval by the Client, a copy of the certificate may be able to be sent directly to RCs or other parties where the pond owner does not wish the full test report to be made available, but alternatively consents to the PDT Certificate being forwarded to a nominated party.

To assist this process, it is suggested that at the time of contract engagement arrangements are made with the PDT supplier for pond-owners to be given the opportunity, to accept or decline their approval, for the supplier to forward a copy of the PDT certificate to the RC on their behalf. RCs have previously advised that for meeting consent conditions, this arrangement could reduce unnecessary administration time by all parties.

REFERENCES

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To facilitate the delivery of this document, DairyNZ as sponsor have engaged WSP NZ Ltd as the lead consultant.

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