Code of Practice
Effluent pond seepage testing

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To facilitate the delivery of this document, DairyNZ, has engaged WSP as the lead engineering consultant.

This Code of Practice was developed by DairyNZ with WSP NZ Limited (WSP) contracted to lead the project.

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This document is the *Code of Practice for Effluent Pond Seepage Testing* and replaces Section 8.6 of *IPENZ Practice Note 21: Part 1: Farm Dairy Effluent Ponds* (Version 3, August 2017) in its entirety.

This Code of Practice 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; and a reference guide for RC's and service providers to the Farm Dairy Effluent (FDE) industry.

Regional Councils need a nationally recognised consistent standard to determine whether effluent ponds within their region comply with acceptable seepage rate limits, as stated in resource consent conditions and regional rules.

The Code of Practice is not intended to be a separate standalone document; it should be read in conjunction with supporting guidance from Practice Note 21.

Developing the Code of Practice was decided by a combination of factors, including:

- the need for a standardised NZ test method for Pond Drop Test (PDT) testing resulting from an increasing range of PDT test methods and report content being offered to pond owners
- the quality and accuracy of PDT equipment used across New Zealand being highly variable
- the introduction of Farm Environment Planning that provides a more frequent risk-based assessment and reporting of effluent storage systems
- the PDT equipment and methodology offered by testing suppliers generally meets the previous Practice Note 21 (Part 1: section 8.6.2) and remains appropriate for identifying gross seepage, however it's no longer suitable to demonstrate pond seepage compliance.

It is intended that this Code would be reviewed, amended, and incorporated into an updated version of Practice Note 21 when sufficient funding and other industry support becomes available.

Contents

Introduction

All ponds, regardless of their liner types, are subject to potential damage from various causes, such as 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 effluent without incurring an unacceptable rate of seepage or leakage loss.

The provisions of this Code of Practice are limited to geomembrane, clay, or concrete lined ponds, and specifically excludes bladder or other types of tanks with flexible walls.

Ponds should be tested for seepage regularly throughout their service life to confirm they are fit for purpose and demonstrates conformance to applicable environmental regulations and resource consents.

Seepage and leakage are often used interchangeably; for this document the word seepage is used.

Pond seepage through pond lining materials can be indicated by various assessment approaches, as listed below by increasing accuracy and test confidence:

a. **Visual Inspection (VI)** of the condition of the lining material and observing typical indication features if seepage was occurring around the pond.

b. **Pond Level Monitoring (PLM)** of changes in pond surface level by simple measurement means while temporarily blocking off all pond inflows and outflows during the monitoring period.

c. **Leak Detection Testing (LDT)** by observing the liquid outflow from a Leak Detection System (LDS) installed beneath an effluent pond's liner to determine whether it may be leaking.

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

Test approaches b) and c) will only provide an indication of whether excessive leakage may be present and are not intended as an alternative for d) for compliance purposes as specified by Regional Councils (RC's).

Engaging a specialist PDT supplier operating a high precision measurement equipment system, along with the supporting test methodology, is essential to achieve the test accuracies necessary for pond owners to submit a complying test report to support their pond liner compliance.

Guidance For New Ponds

Good practice for all new or highly modified ponds is in Practice Note 21 and must be applied to their design and construction. The involvement of a suitably experienced Professional Engineer (who may also be CPEng accredited) is necessary for the majority of new or highly modified ponds for compliance with building and resource consent requirements.

After the pond is commissioned, the pond owner should request a signed Final Completion Certificate from an Engineer who is competent in the relevant engineering practice area to confirm that the pond constructed conforms with the issued design drawings and specifications, has been verified as fully functioning, and meets the following acceptance criteria.

Engineer's 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. within 6 months of the pond's construction completion, that either:

- an initial PDT has been completed, and the pond's measured seepage rate complies with local RC requirements, or
- the approved Leak Detection System does not discharge more than a trace of effluent when the pond is >75% full

and

c. where a geomembrane pond lining is installed, and an appropriate liner type and thickness was installed at the time of construction with genuine warranty certificates of at least:

- 10 years on the lining material, issued by the liner manufacturer, or product supplier, and
- 10 years on its installation, issued by the installing company.

Obtaining this certificate provides confidence that the pond was constructed and designed in accordance with best practice. This should be considered when determining frequency of pond leakage assessments.

Pond Seepage Assessment Tools

3.0 Visual Inspection

In addition to PLM and LDT testing, the landowner should monitor and inspect their FDE ponds, including their interconnecting infrastructure, at least annually, and record observations in their asset management system (Freshwater Farm Plan, Dairy Diary etc).

- Pond level – is there evidence of overtopping? Freeboard should be kept at not less than 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 pond's 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.
- Geomembrane liners can be subject to harsh temperature and Ultraviolet (UV) conditions in New Zealand, and some can deteriorate more quickly than the warranties offered by international manufacturers and suppliers.
- Pond Bunding – are there damp areas on the outer slopes of the pond bund? Look for shrubs or trees with roots that could be penetrating the liner or growing on the anchor trench which provides lateral 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.

3.1 Pond Level Monitoring (PLM)

A simple PLM system can be completed by placing a partially submerged graduated stainless-steel rule fixed to a driven solid steel post at an accessible location at the pond's edge. Alternatively, where the pond liner is at risk of being damaged by the steel post, another fixing arrangement needs to be explored, such as an 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 used.

In preparation for the test, the pond should be 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, high winds or freezing temperatures can be expected. Personal safety measures while undertaking readings must also be considered.

The test involves taking an initial reading (in mm) on the rule at the top of the formed liquid meniscus along with 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 seepage rate in mm per 24-hour day determined.

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

$$\text{Seepage Rate} = \frac{\text{Reading (final)-Reading (initial)}}{\text{Test Hours}} \; x \; \frac{24}{1} \quad \text{(mm/day)}$$

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.

3.2 Leak Detection Testing (LDT)

A well designed and installed Leak Detection System (LDS) can provide an indication of excessive continuous seepage through a pond's liner.
This approach involves carefully collecting and measuring any liquid discharged from under the liner over a timed period.

All new ponds should incorporate a system to periodically confirm that the impermeable liner is continuing to operate as designed. The farm operator should frequently inspect this as part of routine system maintenance.

To maximise the value of the LDS, pond designers and owners should consider the following pond design matters before installation:

- Involve a suitably qualified engineer (who may also be CPEng accredited). including sign-off of the design, construction, and LDS testing.
- Will the system cover and capture the whole underside of an installed liner in the pond?
- How will LDS outflow liquid be collected, measured, and analysed?
- Can the effectiveness of the whole LDS system be physically tested periodically to authenticate it's continued operation without blockages, and function as designed?

Practice Note 21 (Part 1: Section 5.10.1) provides some further guidance. For the purposes of this Code of Practice document, the leak detection test is a simpler on-farm risk assessment. There are options to use a suitably qualified person to undertake a leak detection test to determine levels of losses from effluent ponds, which is more precise than this initial presence or absence test.

Pond Drop Test (PDT)

4.0 Introduction

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

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

To achieve the necessary accuracy, specialist precision measurement technology systems were built to measure fractions of a millimetre. New off-the-shelf complete PDT systems are not available for purchase and PDT test suppliers will need to arrange for the development of their own system using local and internationally sourced components.

Environmental influences like 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 necessary. Detailed spreadsheets or specific software developed for the test analyst are required to examine the data and identify any anomalous readings or sections of data that should be rejected.

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

To minimise the risk of excessive seepage remaining undetected, a risk-based approach needs to be tailored to the farm for site specific risks. Further industry guidance is provided for seepage risk management in farm plan guidance.

4.1 Pond Preparation

The key to obtaining reliable test results is correct preparation of the pond prior to PDT test commencement, and will include the following tasks:

4.1.1 Program the testing

- Forward planning is the key.

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

4.1.2 Clean out 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 affect evaporation rates, and the corrections subsequently applied. It may be necessary to postpone PDT testing until a pond has been sufficiently cleaned out.

4.1.3 Fill up the pond

- At the start of the test the pond must be at least 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 a low point on the perimeter bank.

The 75% minimum prerequisite maximises pond's wetted surface area being tested. It 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 risk to climb down the slope to set up or adjust test equipment that is in contact with effluent.

4.1.4 Do not stir the pond

- Do not stir the pond within the 3-day period prior to the test starting.

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

4.1.5 Identify preferred test site

A location on the pond's perimeter with the following characteristics is typically the most suitable place to site test equipment:

- Close parking for the support vehicle for ease transportation of equipment.
- No fences to cross.
- Easy site accessibility, not having to walk through shrubs, trees, thick long grass, and swampy areas.
- Flatter, easily negotiable slopes, on good stable ground.
- A cleared vegetation site area, where the equipment may be easily and safely placed.
- Close to a pond access ladder (if fitted) or other accessible permanent infrastructure.

4.1.6 Isolate the pond to be tested

- Effluent inflows should be diverted into temporary or other storage where 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 area.
- 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 tracking along the outside of buried pipes.
- While not preferred, inflow from dairy shed washdown may be able to be accepted, 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 total time for the data set analysis is still met, the overall duration of site testing should be extended.

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 should be hydraulically isolated from each other. This may involve earthworks, filling with compaction to temporarily seal the opening between. If they are only connected by a pipe, it must be completely blocked or capped off. An acceptable alternative is to test them as one pond by digging a channel between them at least 1m wide and 1m deep to provide a level gradient with unrestricted flow in both directions.

4.2 Field Testing

4.2.1 Safety

Working near, in, on, or over effluent ponds is a hazardous activity with high safety risks.

Before working 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.

Site conditions and risks posed by working around effluent ponds can change. It may be necessary to re-assess the potential hazards and control measures on site prior to starting 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, and 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 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 must be available that are waterproof and suitable for the location (e.g. satellite-based in remote locations).
- PPE and rescue equipment must be available to the operator. It should be tested and in good working order.
- Wear PPE and clothing appropriate for the work being done. Depending on the site, you may need a safety harness, life jacket, life rings, and employing ladders or safety ropes.

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

4.3 Test Equipment

4.3.1 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. Obtaining written evidence from the manufacturer confirming that the sensor and data logger combined accuracy is less than ± 0.2 mm is strongly recommended.

4.3.2 Uncertainty of Error

Confidence in the reported seepage rate can be difficult to accept by interested parties without also reporting the error uncertainty attached to this rate. The total error is also referred to as the Total Expanded Uncertainty of Error and is the sum of all the contributing individual uncertainties from the various PDT equipment components, and with a 95% confidence applied. The 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%.

'Error' in this context refers to the specific unknowable difference between the measured value and the unknowable true value. '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.

See the References section for uncertainty of measurement guidance literature.

To confirm the accuracy of the PDT system is sufficient, and meets this Code of Practice, it must be assessed and confirmed that it has a:

Total Expanded Uncertainty of Error ≤ ± 1.0 mm

This assessment must be completed by an independent agency that operates calibrated precision measurement equipment traceable to international standards. This may be a commercial metrology supplier or research organisation with specialist capability to undertake and analyse precision measurements and calculate the sum of all the errors from the individual elements that together form the PDT system.

This Total Expanded Uncertainty of Error analysis is to include, but not be limited to, all identifiable components in the PDT measurement system. It includes 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.

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 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 reliant on those reports.

4.3.3 Test Duration

A minimum continuous test measurement duration of 50 hours is required to comply with this PDT test method but should be extended for longer if unsuitable weather conditions occur, or if there have been unavoidable inflows or outflows during the test.

An exception to this 50-hour requirement is where data is being continuously telemetered or manually downloaded from the test site to the analyst; but only if they can confirm that at least 36 hours of acceptable 'good' telemetered data has been received, and the analysed graphed data clearly indicates a clear consistent seepage rate trend pattern before the decision is made to terminate the test.

Following the evaluation of all field data there must be a resulting minimum of 36 hours of acceptable data. This can be made up by accumulating several periods of 'good' data, with the total accepted hours being referred to as the 'Effective Monitoring Period'.

The longer the test duration, the more accurate the resulting seepage rate per 24-hour period can be expected.

4.4 Data Corrections

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

4.4.1 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 excluded from the analysis. The reasoning is that the recorded rainfall depth often does not always exactly align with the actual pond depth increase because the pond surface area is typically smaller than the ponds catchment area. Further, there can be surface channels and other inflow sources which will direct rainfall into the pond 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.

4.4.2 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 approximates actual pond evaporation, and with less variability than alternative land-based pan systems. Therefore, to provide the necessary test accuracy required, land-based pans should not be used.

Evaporation loss (measured in mm) in floating pans can be influenced 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.

In addition, 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 coefficient 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 loss site and closer to 1.00 for minimal evaporation). 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 in their NZ locality.

4.4.3 Data Corrections Summary

To operate within the necessary Expected Uncertainty of Error limits of the test, every possible measurable correction to the data, including rainfall and evaporation, needs to be applied for this precision test.

4.5 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 test data analyst is essential. These factors include:

4.5.1 Groundwater

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

4.5.2 Diurnal Effects

There can be distinct pond surface level changes between daytime and nighttime due to air and water temperature differences. Pond levels can appear to cyclically go up and down and therefore it can be appropriate to analyse data in separate 24-hour sections to reduce the impact of these diurnal effects.

There is a view, not accepted, that as there is less evaporation during the hours of darkness due to lower temperatures and the absence of the sun's evaporative effects, evaporation adjustments can be avoided if the PDT is restricted to nighttime testing. However, this view does not recognise that wind also occurs at night, generating measurable evaporation which still needs to be accounted for.

4.5.3 Wind Speed

Wind can create surface waves affecting recorded levels on both the pond and evaporation pan surfaces. Wind against the side of the pan can cause rocking, or overtopping, 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 may still be acceptable if the close analysis of the data section, post testing, shows that there was no wind impact on the quality of the data recorded.

4.5.4 Anomalous Data

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

The linking together of the time periods during which 'good' data is accepted, and suspect data is rejected, determines the Effective Monitoring Period for the analysis.

Test Report

5.0 Result Reporting

Test reports shall state the assessed seepage rate, which is the unaccountable pond level change during the Effective Monitoring Period, and is in the form of:

Seepage Rate= PDT Test Result ±1.0 (mm/day)

- where the PDT Test Result is determined from the PDT analysis and assigned an 'Expanded Uncertainty of Error' of ≤ ± 1.0 mm from independent precision reference testing
- seepage is expressed as a negative number

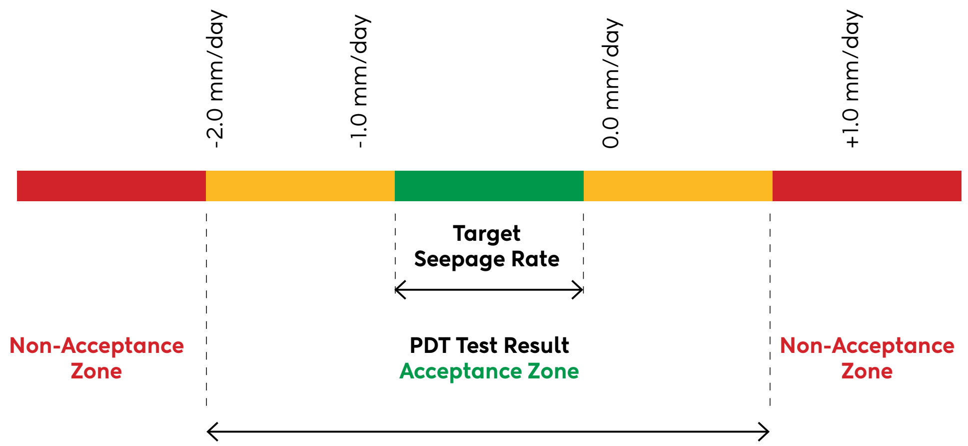
5.1 Seepage Pass/Fail Criterion

Industry recommends an acceptable effluent pond seepage rate as being within the above limits, also expressed mathematically as:

-2.0 ≥ Seepage Rate ≤ +1.0 (mm/day)

- includes an assigned Expanded Uncertainty of Error of ≤ ± 1.0 mm from independent precision reference testing
- seepage is expressed as negative number

Or graphically as:



PDT suppliers will provide a result which aligns with the PDT test result acceptance zones described in the image above. A consideration in the setting of any pass/fail criterion may be whether the depth of the pond is a significant negative contributing factor. Deeper ponds have a higher hydraulic head than shallower ones and will therefore have a higher seepage rate for the same liner condition. Practice Note 21 (Part 2: Section 2.3) explores this matter further and should be discussed in the PDT report if relevant.

5.1.1 Report Information

The test report should contain all information to understand how the reported seepage result was obtained, supported by other relevant site details. As a minimum, the following details should be included in the PDT test suppliers report to their clients:

- Pond owner name, and address
- Pond location and identification
- Estimated pond dimensions
- Condition of pond
- Test method details
- Environmental data: rainfall, evaporation, wind, other
- Change in pond level, including the corrections applied (mm)
- Test start and end times/dates, test periods included/excluded in the analysis
- Effective monitoring period (days/hours)
- Assessed Seepage Rate (mm per day)
- Factors that may have affected reported results
- Graph of changes in pond level, and environmental data recorded during test
- Aerial plan, and photographs of the test equipment, pond and surrounds
- Name, signature and date of both the analyst and the CPEng reviewer.

While an engineering inspection of the pond site is outside the scope of the PDT test, any observable concerns by the PDT field technician contributing to seepage should be recorded as observations on the PDT report. Observations may 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 must be reviewed with the report signed off by a New Zealand Chartered Professional Engineer (CPEng) with accreditation and competence in a relevant practice area. There is one permissible exception for this CPEng sign off, to save unnecessary cost, and this is where the test is a clear (but not marginal) 'fail'. The report must still state the calculated seepage rate (mm per day) to provide an indication of the assessed leakage rate to their clients.

5.1.2 Test Limitations

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

- Where the client, or a member of their staff, provides information to a third-party, or where the supplier has obtained and/or relied upon information provided from another party, the supplier has not verified the accuracy of this information. The supplier assumes no responsibility for any inaccuracies in, or omissions, arising from 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 supplier is not responsible because of any such changes.

5.1.3 PDT Certificate

Subject to their approval, a separate accompanying PDT Certificate can be issued to the client with the test report. This Certificate should contain (as a minimum) the following related test information:

- Pond owner name and address
- Pond location and identification
- Testing date
- Seepage rate in mm per 24-hour day
- Engineers name, company, and dated signature.
- Any other information the Client wishes to be added to the PDT Certificate.

A copy of the certificate may be sent directly to the RC, or other parties where the pond owner does not wish to disclose the full test report 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, that pond-owners be given the opportunity to accept or decline their approval for a copy of the PDT certificate to be forwarded directly to the RC on their behalf. RC's have indicated that for meeting consent conditions, this arrangement could reduce unnecessary administration time by the parties.

References

Differences in Evaporation Between a Floating Pan and Class A Pan on Land

J.R. Masoner, D.I. Stannard, S. C. Christenson (2008), Journal of the American Water Resources Association, Index 70033462. https://doi.org/10.1111/j.1752-1688.2008.00181.x

Uncertainty of Error

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.

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