HWM

User Guide: Hydrophone 2.
Sound sensor for loggers.
Sound sensor kit for correlators.

Warning: ⚠	This manual contains important safety and operating information. Please read, understand, and follow the instructions in the manual and also any safety / approvals Safety Supplement documents shipped with the device.

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1 INTRODUCTION

Thank you for choosing a HWM device. We trust it will provide you with many years of service.

The "Hydrophone 2" is a sensor device. The sensor can be used with various types of HWM equipment and applications. Hydrophone 2 applications include:

- Use by certain HWM loggers for detection of water-leaks from a pressurised water pipe network.
  (i.e., To detect that a leak *is near*; a leak-like noise has reached the logger sensor). Hydrophone 2 sensors are used to improve performance (when compared to the 'dry-contact', accelerometer type sensor with a magnetic base) on traditionally difficult leak detection situations, such as on plastic and larger diameter pipelines.

- Use by certain HWM sound correlator devices for detecting the most probable location of a water leak on the water pipe network.
  (i.e., To *pin-point* the leak location).
  The Hydrophone 2 can be used with HWM Digital correlator systems including the "Touch", "Touch Pro", "Touch Pro TM", and "Tri-Corr".

The sensor unit connects to 'wet' fittings that allow access through them into the water column, (e.g., hydrants, washouts, or meter points). The hydrophone sensor itself is an extremely sensitive marine sensor, which listens within the water column.

Typically, leak noise travels greater distances through the pressurised water inside the pipe, than through the pipe wall and fittings. Low frequency noise also travels best through water; hydrophone sensors are particularly sensitive to this low frequency noise.

The Hydrophone 2 sensor can fit directly to certain fittings. Where this is not possible, a range of adapter options will allow easy connection to many other fittings. A bleed valve is available through which air can be removed from the sensor chamber to ensure the best quality sound. The bleed valve can also be utilised as an access point to the water column for applications that required water pressure to be monitored.

1.1 DOCUMENTATION AND SUPPORT OF PRODUCT

This user-guide covers the following model families:

Model Number(s)	Description
S16S / 1 / *	Hydrophone 2 sensor. (Requires a logger model with a compatible interface for use).
HYDKITMCT *	Kit – 2 x Hydrophone 2 sensors (+ accessories). (For use with compatible HWM correlator systems).

It gives detailed information for the use of Hydrophone 2 with various HWM loggers for detection of possible water-leaks in a water pipe.

For use of Hydrophone 2 with sound correlator devices, this user-guide gives introductory information only; Refer to your correlator user-guide for additional information).

The user-guide should be read in conjunction with the user-guide(s) of the equipment it is being used with. Read any Safety Warnings and Approvals Information supplied.

For setup with logger devices, also read any appropriate sections of:
MAN-130-0017   IDT (PC version) user-guide.

Note: HWM periodically updates software to include new features and any required changes, thus you may observe slight changes from the diagrams and features shown in this manual.

HWM provides support by means of our customer support webpages:

https://www.hwmglobal.com/help-and-downloads/

Should you have any questions that are not covered by this manual or the system's online help, please contact the HWM Technical Support team on +44 (0) 1633 489479, or email   cservice@hwm-water.com

1.2 SAFETY CONSIDERATIONS

Safety Note:

Before continuing, carefully read and follow the information in the "**Safety Warnings and Approvals Information**" document supplied with the product.
This provides general safety information.

Safety procedures:

Working with water and other fluids under pressure can be hazardous. Recommended safety procedures for working conditions must be followed at all times, and operational procedures described in this manual should not take precedence over local safe working practices or company procedures. If in doubt, ask your local safety officer.

Use of correlation equipment with the water supply is subject to the hygiene procedures applicable to any objects coming into contact with drinking water supplies. Hydrophone sensors and adaptors should be appropriately sterilised prior to use and applicable procedures should be followed during their installation.

1.3 OPERATING TEMPERATURE

Refer to the Hydrophone 2 Datasheet and also the Datasheet for your logger (or consult your sales representative) for guidance on the storage and operating temperature range of the equipment. Ensure the equipment is within the operating temperature range prior to installation.

2 DESCRIPTION, APPLICATIONS / SUPPLY OPTIONS

2.1 HYDROPHONE 2 DESCRIPTION

The Hydrophone 2 sensor is shown opposite

The upper part of the sensor contains an electrical connector and also an auxiliary connection point to the water column.

The auxiliary access will accept a series 21 quick coupling.

The body of the sensor has flats that will accept a 50mm spanner, or alternatively a custom tool (available from HWM) for installation where access space is limited.

Auxiliary access (for bleed valve)

Electrical connector

View showing cable and bleed-valve connections.

The lower part of the sensor contains a small chamber, which provides some protection to the sensing element of the device. It also has an aperture to give access to the pressurised water column.

(Note: Threads not shown).

Remove any thread protection covering prior to use

Auxiliary access (for bleed valve)
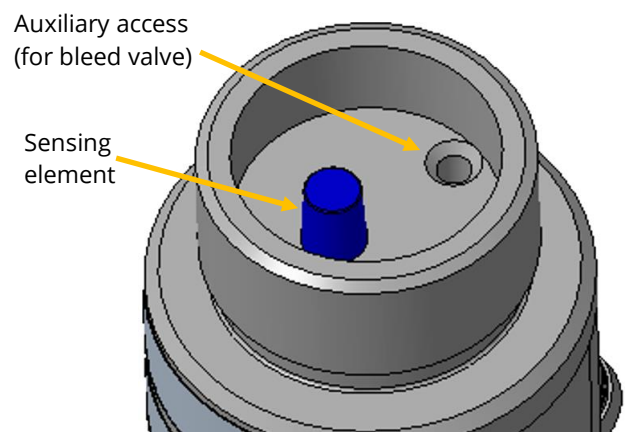
Sensing element

View showing sensing element and vent aperture

A label on the sensor will show the "Hydrophone 2" name. It includes the part-number, serial number, and any approvals logos applicable to the supplied unit.

HWM HYDROPHONE 2

PN XXXXXXXXXXXXXX
SN XXXXXXX

BARCODE

HWM-Water Ltd, NP44 3AW, UK
www.hwmglobal.com

Fcs HYDROPHONE 2

PN XXXXXXXXXXXXXX
SN XXXXXXX

BARCODE

Fluid Conservation Systems,
Milford, OH 45150
www.fluidconservation.com
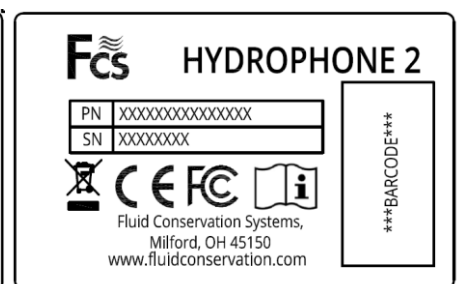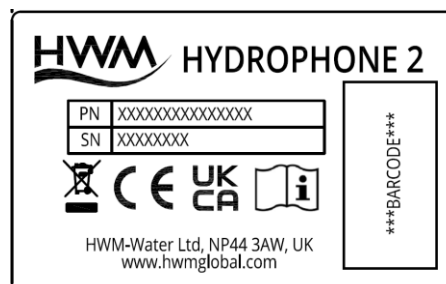
The outer ring of the chamber is threaded, 1.5 inches BSPP.

The Hydrophone 2 is supplied with an O-ring which is used to seal the surface between the hydrophone and an adaptor.

Thread
1-1/2" BSPP

O-Ring

(Sensor chamber)

Various adaptors can be fitted to the Hydrophone 2.
Select a suitable one for use with the asset (valve, hydrant, etc) to which the Hydrophone is going to be connected.

An example of an adaptor is shown opposite.
(This is the 1.5-inch BSPP to 2.5-inch London Round Thread Adaptor).

The electrical connector is a waterproof 4-pin mil-spec connector.

A suitable cable is required to connect the Hydrophone 2 to the logger unit (or correlator equipment). (See section 5.1).

2.2 THE HYDROPHONE 2 SENSOR (SINGLE UNIT)

The Hydrophone 2 is available as a sensor option for certain HWM loggers that operate to detect leaks in pressurised water pipes. This application requires only one sensor.

The Hydrophone will typically connect to the interface labelled "LNS" or "Comms and LNS" (or similar).

When ordering the logger and sensor, ensure an interconnecting cable is also ordered ; this must be of a suitable length to reach where the logger is going to be mounted.

In addition, consider any adaptors that may be required to join the Hydrophone 2 to the pipe network.

2.3 ACCESSORIES

When fitting the Hydrophone 2, the installer will require certain tools and accessories, available from HWM: (These can be re-used for many Hydrophone-2 installations).

- A quick-fit bleed kit for Hydrophone 2.
- An installation tool (for use where there is no space to use a spanner / wrench).
- A USB logger programming cable.
  Some logger families use their regular programming cable. Other logger families require an alternative programming cable when used with the Hydrophone 2 (i.e., a temporary Y-adaptor cable ; provides a logger to hydrophone connection and also a logger to USB connection for programming with a PC. See also section 2.3.3).

2.3.1 Quick-fit bleed kit

The quick-fit bleed kit comprises a coiled hose with quick-release connectors. A tap is included.

The kit allows for a temporary connection to the quick-release connector on Hydrophone 2 in order to bleed air from the chamber (using the tap) and thereby allowing the sensor element to have good contact with the water column.

Note: Water must be discharged safely when using this kit.

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2.3.2   Installation Tool (socket)

The installation tool is used to tighten and
release the Hydrophone-2 to the opening of the fitting
(valve, hydrant, etc).

The tool has a 1-1/4-inch square drive to allow it to be driven by a
standard valve / hydrant key.

The 50mm wide U-shaped end is designed to be seated onto the
Hydrophone 2 as shown in the diagram opposite.

Large slots allow the exit of any cable attached to the Hydrophone 2,
if fitted.

When used, the tool should be positioned as shown and then lowered
onto the Hydrophone body. A hydrant key can then be used for
tightening or removal purposes.

2.3.3   Programming cable (Y adaptor)

Certain logger families require a Y-adapter cable (rather than their regular
programming cable) in order to program the logger and to be able to test the
Hydrophone 2 sensor is functioning whilst on-site.

(To PC USB)

(To Logger)

(To Hydrophone 2)

The following logger families support Hydrophone-2 and require the use of the
Y-adaptor cable: (The cable part-number is CABA9349).

- PermaNET+   ; the programming interface and the LNS interface
                            share the same logger connector.
- PermaNET+ TM   ; (as above).

The following logger families support Hydrophone 2, but do not require the use of the
Y-adaptor cable:

- Multilog LX2   ; the programming interface is an optical coupler unit.
- Multilog 2   ; the programming interface is not shared with Hydrophone2.

2.4 THE HYDROPHONE 2 KIT (HYDROPHONE-2 PAIR AND CARRY-CASE)

The Hydrophone 2 is compatible for use with certain HWM correlators. This application (to determine leak location within the pipe) requires a pair of Hydrophones to be supplied. The Hydrophone 2 kit is usually supplied as an upgrade option for HWM correlator systems (which are normally supplied with accelerometer type sensors with a magnetic base coupling).

A plastic case is available with foam cut-outs that can securely and safely store a pair of Hydrophone 2 sensors, some couplers, a quick-fit bleed hose with tap, cables for use with the correlator, etc.
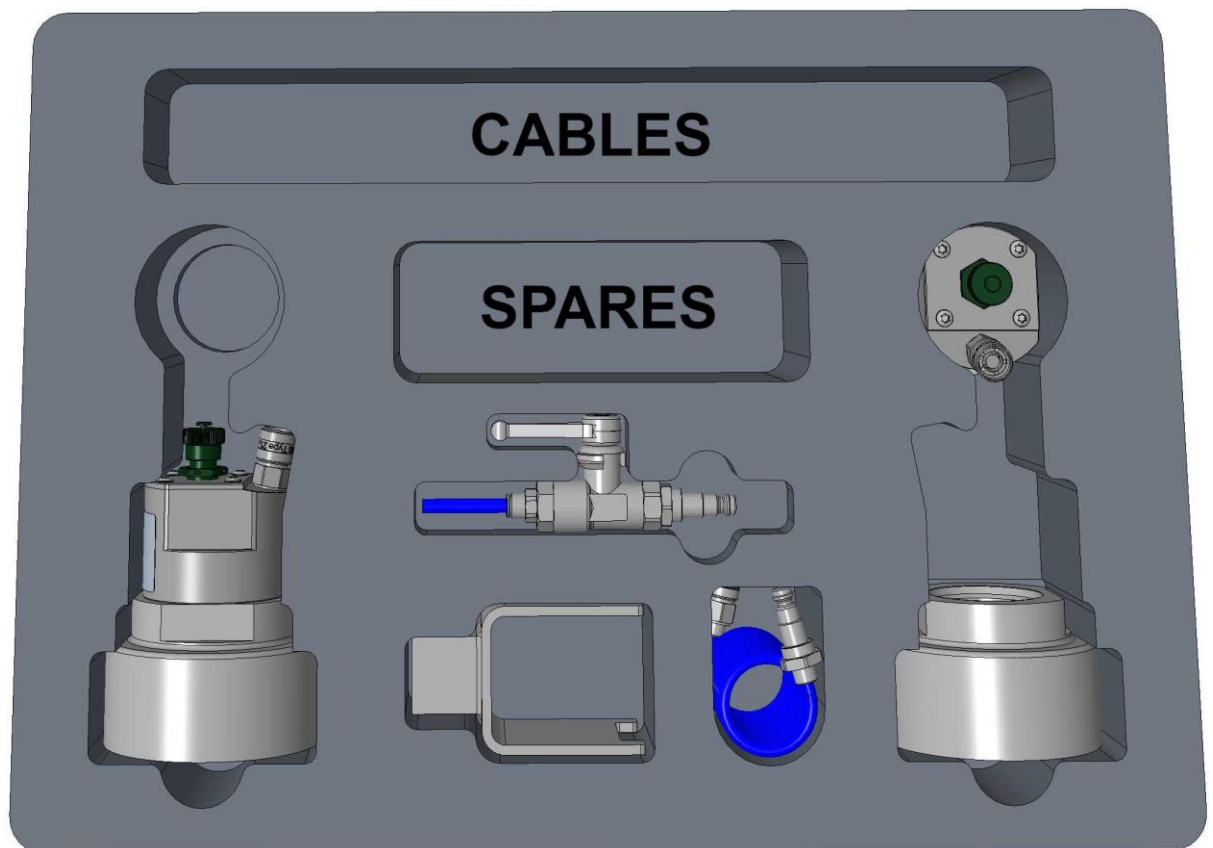
(Note: For illustration purposes only. Contents and layout may vary according to the kit supplied).

Note: Most parts supplied in the kit are identical with those for single loggers.
        However, the cables are compatible with correlator use only.
        There is no programming cable included ; The correlator includes its own
        console for setup.

Note: For details of use of the Hydrophone 2 kit with a HWM Correlator, please refer to
        the relevant correlator user-guide.

3 USE OF HYDROPHONE 2 WITH A LOGGER (BACKGROUND)

Hydrophone 2 sensor is compatible with a variety of HWM loggers, including the following logger families:

- PermaNet+
- PermaNet+ TM
- Multilog LX 2
- Multilog 2

Compatibility with each logger will depend on the interfaces and options fitted to the logger during factory build.

The logger may operate in one of the following three modes:

- A logger may be singularly interested in determining if a leak is present, and runs a leak determination program once per day, during a quiet period (when water use is likely to be minimal).

- A logger may be singularly interested in determining if a leak is present but is required to detect it rapidly. It achieves this by running a shorter leak determination program regularly during the day.
  (This type of operation is usually needed on the trunk main pipe network; loggers with a name ending in "TM" can operate in this way).

- A logger may be interested in determining if a leak is present but is also required to monitor (frequently log) other types of physical parameters (e.g., water flow, water pressure).

Setup of the logger will vary according to which of the above modes of operation is required.

Prior to considering installation and setup of the Hydrophone 2 with your logger, some background information is provided …

3.1 LOGGER – DEVICE OVERVIEW

Note: Most loggers are supplied with standard settings for operation programmed into them prior to shipping from the factory, with some variations according to customer requirements. The installer may check or be required to adjust certain settings to suit the particular installation site.

For loggers that are required to repetitively log other types of physical parameters, refer to the logger manual and IDT manuals regarding how the logger operates, what data is stored, and how to set up these channels. This manual deals specifically with the operation of the logger when using the Hydrophone 2 as a leak-noise sensor, what data is produced, and how to set up the logger to use the sensor.

The logger being used with Hydrophone 2 requires a suitable interface. This must be fitted to the unit when it is being built; it is not possible to add it after construction.

The Hydrophone 2 (once connected) is of a waterproof construction, being designed to be permanently installed (with the host logger). A fleet of such systems are intended to be installed around a water network, listening for leaking pipes. The devices accomplish this by means of a specialised microphone (the Hydrophone 2) that can detect the sounds that occur within a pressurised water network; In particular, they are listening for the types of sounds that could be emitted from a pipe leak.

Note: The logger regards the Hydrophone 2 as a type of Leak-Noise sensor (or 'LNS' sensor device).

A micro-controller, built into the logger unit, measures the noise levels at certain times during the day and then performs a statistical analysis to generate further data. Two different algorithms are employed to produce and analyse the data, depending on whether the logger is operating in a standard (daily leak evaluation) or a Trunk Main (continuous leak evaluation) mode. In addition. a leak-state judgement is made by the logger. The results are saved in memory, for upload to the server at a later time. Where the Trunk Main type operation is in use, the logger can provide a more urgent alert to a possible leak condition by sending an alarm indication.

3.1.1   Logger leak evaluation modes

The logger will operate its leak-detection function in one of 2 distinct modes:

- A daily leak-evaluation mode, or
- A frequent leak-evaluation mode (this is known as the "Trunk Main" mode).

The modes are further discussed in sections 3.1.2 and 3.1.5.

3.1.2   Measurement data types

The data produced by the logger depends on whether it is operating in the standard (daily leak-evaluation) mode or the Trunk Main (frequent leak evaluation) mode.

Daily leak evaluation mode:

The saved data could be in the form of:
- A "noise histogram".
    This provides a detailed indication of how consistent the noise measurement is and can be used for more advanced analysis. Histograms can also help to visualise the noise into patterns that can be identified as leaks.
    (Noise histograms do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).

- LNS Level and LNS Spread (numeric indications).
    These two figures are a numeric summary of the noise histogram.

    o The "Level" figure represents the sound level that occurs most often during the sample period.

- The "Spread" figure is how much the sound level varies during the above time.

    (A large consistent Level and small Spread is typical of a leak, whereas a small Level and large Spread is typical of background noise within a pipe).

- A "leak / no-leak" status.
  This gives a simple indication of whether results indicate a probable leak.

- Sound recording files.
    (Sound recordings do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).

Trunk Main evaluation mode:

The saved data could be in the form of:

- LNS Level (minimum, average, or maximum), and LNS Spread; (these are numeric indications).
  These figures are regularly logged datapoints that provide an ongoing numeric indication of the noise within the water pipe.
  The "Level" figure represents the sound power level within the water pipe.
  The "Spread" figure is how much the sound power level varies during the time between log periods (i.e., maximum – minimum power).

    (A large consistent Level and small Spread is typical of a leak, whereas a small Level and large Spread is typical of background noise within a pipe).

- A "leak / no leak" indication (status).
  Note: This is a series of judgements made at the time when each log period (sample acquisition) ends.
  This gives a simple indication of whether results indicate a probable leak.
  (Since the evaluation is made frequently, at the log intervals, there can be some instability in this result ; It will require further filtering by the logger to stabilise).

- Sound recording files.
    (Sound recordings do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).

3.1.3   Battery / lifetime

The host logger is powered by non-rechargeable Lithium batteries. The Hydrophone-2 itself contains no batteries ; it is powered by the logger whenever the sensor is needed. The logger is designed to minimise the battery use and thus increase the life expectancy of the unit (e.g., the loggers become active when needed; most of the time they are in standby). The battery life is also affected by user-programable settings. The user should therefore set the logger with the view of preserving the battery power. (e.g., Use the longest intervals between sampling that can still produce the required data and results).

3.1.4   Communications with a Laptop computer / Mobile phone

Depending on the logger family being used with Hydrophone-2, the logger will include either a serial communications interface or a Bluetooth interface; refer to your logger user guide. This enables the user to communicate with the logger during installation and make on-site tests including test of the Hydrophone 2 sensor. (Refer to your logger user guide for details of the interface and software tools required).

3.1.5   Logger operation - Repetitive functions & Leak detection modes

The logger is normally shipped from the factory in a minimally active state, to extend battery life whilst in storage (e.g., no measurements are made or logged). This mode is designed for periods of storage or shipping of the device, with the logger referred to as being in "shipping mode", or "sleeping". Once activated (see your logger user guide), the logger no longer sleeps, but begins its repetitive daily tasks.

Whenever possible it saves power by putting circuits it does not currently need (e.g., Hydrophone-2) into a "standby" condition. However, the logger will become highly active at the time it is required to make any sound measurements, complete its leak evaluation, and store the results within its memory. The logger will then go into standby until the next programmed event is due or a sensor reading is required.

<u>Operation with standard Daily leak evaluation mode setting:</u>

The logger's primary task is a leak-sensing program, which runs once daily. The Leak-state evaluation program is extensive, taking up to 2 hours to complete. It takes place between 2-4am (although it can be changed). Typically, it is made during a time of low water use to reduce the possibility of consumer water use being incorrectly judged as a leak. During this time, the logger makes an initial evaluation. if the logger determines a change of leak-state (a potential new leak), it waits for some time and then carries out a second confirmation evaluation (double check); This reduces temporary noises being mistaken for a leak indication.

If the logger determines that a new leak is likely to be present near-by, it can (if so set) automatically make a sound recording when the new leak is detected. The sound recording is by default 10 seconds in duration.

The logger therefore produces one leak-status determination per day. It waits until its scheduled call-in time and uploads its data to the server.

Office staff can evaluate the leak status of an individual site (results from a single logger) or look at the leak status of the local pipe network (results from many loggers) using the appropriate data viewing tool (via a website).

Note: Loggers using this mode can also support regular repetitive logging tasks; other types of sensor interfaces can also be fitted to the logger. (These can only be fitted during logger production).
The LNS driver navigates around other regular sensor sampling activities.
However, ensure call-in times do not collide with any sound recording activities.

Operation with Trunk Main evaluation mode setting:

The logger uses a much shorter leak-sensing program, which takes only a fraction of a second to complete and runs repeatedly throughout the day. The Leak-state evaluation therefore produces a continuous stream of results, rather than a single daily judgement.

Note: Since the leak evaluation can be made in a short time, loggers using this mode can also support regular repetitive logging tasks; other types of sensor interfaces can also be fitted to the logger. (These can only be fitted during logger production).
The LNS driver navigates around other regular sensor sampling activities. However, ensure call-in times do not collide with any sound recording activities.

The Trunk Main mode is designed to provide a rapid alert when leaks are detected. This is accomplished by setting the logger to call-in with an alarm indication upon detecting a probable leak. This requires an alarm to be programmed with the logger settings.

Because the leak status indication is a continuous stream of datapoints, it is possible that the raw data may occasionally "flap" (rapidly change between leak and no-leak indications). When setting the alarm trigger conditions, it is possible to filter this out and only send an alarm when there are definite indications of a leak. At this time the logger can also (if so set) automatically make a sound recording. The sound recording is by default 10 seconds in duration. After making any sound recording, the logger then makes a call-in to send the alert and upload its data to the server.

(Note: The automatic sound recording becomes scheduled when any alarm condition becomes active, not just the one created for the leak detection).

Office staff can evaluate which sites are indicating a leak status using the appropriate data viewing tool (e.g., via a website). An area containing multiple sites (with loggers) can be interrogated for those that have an active alarm for a leak condition.

Note: Making and transmitting sound recordings can use a lot of data and also drain the battery significantly if too many are made. In order to preserve battery life and reduce data costs, the recording system is restricted to 7 recordings a month. If you have a specific requirement for more than this limit, then please contact HWM customer service for assistance.

When available, sound recording files can be used to confirm whether the sound within a pipe does resemble the sound produced by a leak.

If several sites in the area have loggers that have produced sound recordings at precisely the same time, the approximate location of the suspect leak can often be found, using a process called Leak Localisation / Correlation.
(Availability depends on data viewer being used).

Note: Always use a ground microphone to confirm a leak location prior to commencing repair works.

3.1.6 System Overview

The loggers (with Hydrophone 2 sensor) form only a part of a functioning system. A typical system will comprise of:

- A fleet of loggers (with Hydrophone-2, or other type of Leak Noise Sensor). These are set to evaluate the sounds within a pipe to determine if a leak could be present nearby.

- A Laptop PC (with Microsoft Windows). The laptop PC can (with HWM software installed and a suitable comms cable) provide a Graphical User Interface for the installer, giving the installer access to set up and test the logger.

- HWM IDT software tool: "IDT (PC version)" application software (installed on the PC). A software tool (**I**nstallation and **D**iagnostic **T**ool) used to check or modify logger setup and to put the logger into various modes in order to test it within an installation.

- A server, set up to receive logger messages and data. The server acts as data warehouse, safety storing the logger data and also providing it to the authorised viewing platform. This is typically the HWM Datagate server.

- A User-account and password for the HWM DataGate system (for administration purposes).

- A User-account and password for the chosen data viewing website (for viewing your data / leak determination results, possibly along with some results from other sensors).

    o When using the standard daily leak evaluation mode, the HWM PermaNETWeb website is often used.

    o When using the Trunk Main evaluation mode, the HWM DataView website may be used.

    Refer to your HWM representative regarding the selection of a data viewer website most appropriate to your needs.
    This discussion should include any other sensor data that the logger may be producing.

Note: The term "DataGate" is used throughout this manual.
        An alternative name may be used by the server in your location
        (e.g., OmniColl).

3.1.7 DataGate – Terminology and Summary

This section *introduces the terminology* that is used by DataGate and the IDT…

The destination of PermaNet+ logger data is usually the DataGate system, provided by HWM. DataGate and PermaNETWeb webpages are the main administration and viewing portals for logger and site data.

An overview of the scheme is summarised here...

HWM **logger devices** produce several forms of measurement data, each of which can be considered as a data **channel**. The data represents a measurement made by a logger deployed on the pipe network. Access to the pipe network is often available through various chambers that house valves or hydrants, connected to the water pipes. A chamber can be used as an installation **site** for a logger. A site may be one of many in an area of inter-connected pipework (which may be known by various names (e.g., zone, district, suburb, area); some areas of the water network may include a water meter to monitor water use, which DataGate can refer to as a District Metered Area (DMA). Sites in a certain area may therefore be collected together in a group, often referred to as a **DMA**. DMAs, in turn may be collected together in a group, referred to as an **account** (or Zone). Each of these separate entities may be represented on a database, such as one used by the **DataGate** system, which links some of them to a **User** of the system.

Or, put in reverse order...

- **DataGate** contains a database.
- A **User** of Datagate can be linked with an account.
- An **accoun**t can be a group of multiple DMAs.
- Each **DMA** can contain multiple sites.
- Each **site** can have one logger device installed at any given time (or none).
- Each **logger device** can produce multiple **channels** of measurement data.
- The **data** of a channel may consist of multiple samples that are obtained at different times. It is linked to the site on which the logger is deployed.

The data produced by each logger is uploaded to DataGate. DataGate links the measurement data of each logger to the correct site.

3.2 OVERVIEW OF THE INSTALLATION PROCESS (LOGGER & HYDROPHONE)

The deployment process depends on the strategy employed by the water company.

An example of Installation may consist of the following steps...

- DataGate must be prepared to receive data from the logger; this is an administration process.
- Installation sites must be selected. These should have a description and reference number to identify them on DataGate.
- Equipment must be available at the installation site to complete the installation. This will include any adaptors or couplings required to connect between the Hydrophone-2 and the water network valve.
  This will also include an antenna. It is possible that several antenna configurations may need to be tried in order to get a good result. It is useful to have a variety of antenna types to try.

- The installer must activate the logger (using the method described in the logger manual) to take it out of shipping mode.
- The user connects a communications cable between the PC and logger. IDT can be used to read current settings from the logger into the computer memory.
- The user should check and (if required) adjust the settings of the logger for the Hydrophone-2 use and the leak determination process settings.
- (Optional) Test the Hydrophone-2 using the IDT tool prior to installing.
- Prepare the Hydrophone-2 and couplings for connection to the water valve. Ensure they are suitably clean and sterile. Ensure the bleed valve is closed.
- Ensure the valve to which the Hydrophone is being attached is suitably clean and sterile.
- If required, occasionally lubricate the threads and other connecting surfaces to ensure they do not become permanently bonded.
- Fit the Hydrophone-2 to the water valve whilst ensuring any health and safety requirements or work practices for undertaking work on pressurised water pipes are followed. Undertake a risk assessment prior to commencing work.
- Bleed the air from the Hydrophone-2 sensor chamber using a bleed kit.

Following the above steps, proceed as per the guidance within the user-guide for the logger:
- The user should check and (if required) adjust the generic settings of the logger. (Call-in schedules, etc).
  Alternatively, leave the logger settings in their factory-set configuration.
- The antenna is connected to the logger. The antenna location within the installation chamber is then determined (this may need to be adjusted later; it is a trial-and-error process).
- (Optional). The user can (whilst the chamber lid is off) make a Call Test to DataGate to verify internet connectivity settings are OK and that data can be sent.
- The lid of the chamber is closed (unfortunately, this degrades the signal with the mobile phone network), and the power-level received from the mobile network (e.g., CSQ level) is checked. If inadequate, adjustments need to be made to the antenna position, or the type of antenna used, to find the best CSQ level.
- With the lid of the chamber closed (and positions finalised), a further Test Call is made to confirm the logger can send and receive data.
- Remove any temporarily used cables from the logger and connect the permanent cables.
- The HWM logger goes to into standby until it needs to make leak determination measurements or send in measurement data. Periodically it completes these tasks.

4 FITTING / REMOVING THE HYDROPHONE 2

4.1 SAFETY / HYGIENE

Warning: When fitting or removing the Hydrophone 2 to an asset (water valve, Hydrant, etc) be aware that very high pressures are likely to exist which can present a hazard of injury to the installer. Make a risk assessment before proceeding and ensure adequate safety measures are in place. Wear any Personal Protective Equipment required during any fitting and removal processes.
Ensure any required safety or water hygiene practices are being followed.

4.2 ELECTRICAL CONNECTIONS – PROTECTION DURING INSTALLATION

The electrical connection to the hydrophone should be kept dry and clean of dirt and debris.

It is recommended to attach the hydrophone side of the cable to the Hydrophone-2 prior fitting, to prevent contamination of the connector with water or dirt, especially if access is restricted due to limited space. Similarly, it is recommended to keep the cable attached when removing the Hydrophone-2, until the risk of water or debris contamination is negligible.

4.3 HYDROPHONE-2 PRE-INSTALLATION TEST

Prior to installing the Hydrophone-2, it is recommended that a pre-installation test is made to confirm the unit is functioning correctly.

Temporarily connect the Hydrophone-2 and use the test procedures described in section 7.1.3 to confirm the hardware is functioning correctly. This confidence test can prevent the need of extra work required to remove the Hydrophone-2 from a fitting if a problem should be discovered later on in the installation process.

Note: In order to complete the tests, the user should be familiar with the contents of the whole of this user guide; communications with and setup of the logger for Hydrophone-2 use are described in later sections.

4.4 REQUIRED PARTS AND TOOLS

Before commencing, ensure that you have the following equipment to install:
- A Hydrophone-2 sensor.
- A HWM logger which includes a suitable interface for Hydrophone 2.
- A cable to interconnect the Hydrophone-2 to the logger.
  (e.g., CABA2715).
- A set of suitable couplings (and seals) to connect the Hydrophone-2 to the fitting being used on the installation site.
- An antenna for the logger unit.
- (Any other mounting accessories, sensors or options that are required to be installed at the site).

The following tools and consumables may also be required:

- Silicone grease (suitable for use with fittings for potted water).
- Seals (various types, depending on fitting and adaptors selected)
  (These are required to seal the Hydrophone-2 to certain adaptors, between any mid-stage adaptors, between adaptors and fitting).
- HWM Hydrophone-2 bleed kit (a hose with quick-connect fittings and a tap).
- Hydrophone-2 Installation tool / valve key to use with the tool.
- PC with IDT pre-loaded.
- PC to logger communications cable. (The type depends on logger being used ; Refer to your logger user guided. A Y-cable adaptor may be needed ; refer to section 2.3.3).
- 50mm and 60mm spanners (wrench).
- PTFE tape.

4.5 PREPARING THE WATER ACCESS CHAMBER

Prior to fitting the Hydrophone 2 assembly to an asset, the water access chamber should be prepared by clearing of any debris. If required, excavate the chamber to ensure the valve can be easily accessed.

Safety note: DO NOT use your hands for installing the sensors in valve/hydrant chambers or meter boxes without checking for foreign objects. Sharp objects such as disused syringes can easily pierce gloves. If any excavation is required, **use suitable tools**.

The Hydrophone-2 must be installed within a chamber that is free of water. Pump any water from the chamber as and when required prior to and during installation.

4.6 PREPARING THE HYDROPHONE

Prior to fitting the Hydrophone 2 to an asset, it must be prepared for assembly with whatever adaptors are required to match coupling point of the asset.

Ensure the parts are hygienically clean prior to assembling.

Ensure the O-ring is fitted and in good condition.

Whenever required, apply a light coat of silicon grease to the thread area of the hydrophone and also the O-ring, to ease assembly (and later disassembly).

Ensure any silicon grease present does not contain trapped dirt or debris ; If contaminated, thoroughly clean the surfaces and re-apply fresh grease.

O-Ring

Thread
1-1/2" BSPP

Apply silicon grease

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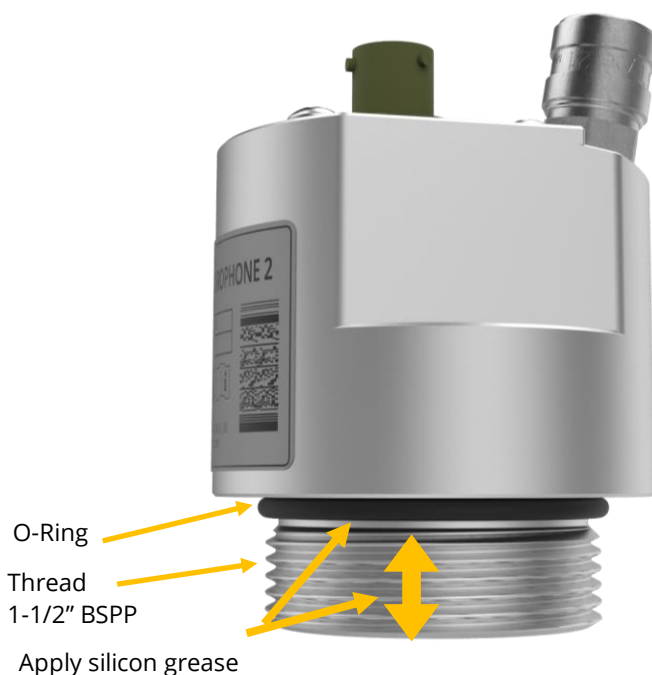
4.7 SELECTING AND PREPARING ADAPTERS

Connection of Hydrophone-2 to an asset (hydrant, valve, etc) will sometimes be direct, but it will often require the use of adaptors in order to change the Hydrophone-2 thread connection into the required thread (and seal) to use on the asset.

Due to the large number of hydrant connections in use globally, adaptor kits are tailored to the needs of the local market. Contact your HWM representative regarding your specific adaptor needs to check for availability and its construction.

For some connections, a single stage adaptor may be available. Sometimes multiple adapter stages may be used in order to reach the desired connector type.

(No adaptor required).　　　　(Single-stage adaptor).　　　　(Multi-stage adaptor).

Note: Adaptor images are for illustration purposes only, and may vary from the adaptors supplied or installed.

(Connection on Asset)　　　　(Connection on Asset)　　　　(Connection on Asset)

Ensure the upper and lower circular surfaces of any adapters
are clean and free of debris; The surface may form part of a high pressure water seal when it comes into contact with another adaptor or the O-ring of the Hydrophone 2.

Ensure any required seals for the adapter are fitted.

Ensure any seals of the adaptor are clean and free of debris.

Ensure the seals are in good condition. (Replace if required).

Lightly coat any rubber seals with silicone grease along any surface that will come into contact with another surface.
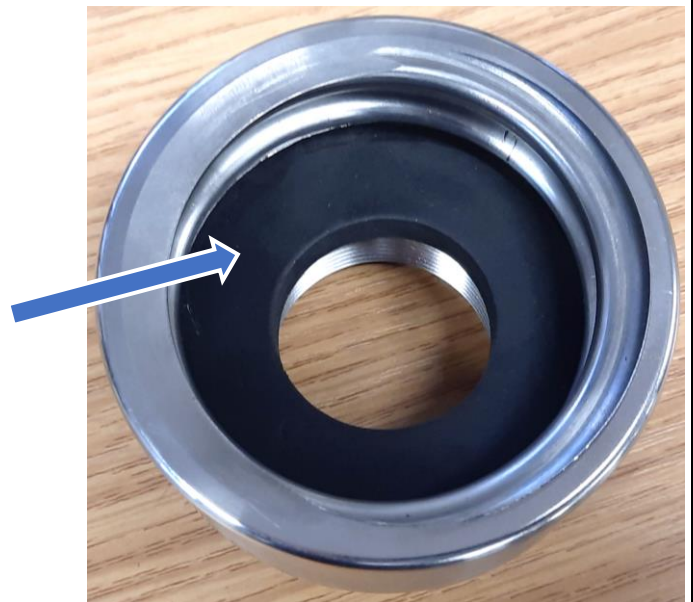
Apply a light coat of silicone grease to lubricate the two screw threads of the adaptor (internal or external threads).

Prior to fitting the adaptors and Hydrophone assembly to the connection point of the asset, plan how to assemble the parts together.

Sometimes the Hydrophone may need to be assembled to the adaptor first (outside of the chamber), due to space restrictions not permitting the use of tools to tighten the assembly. The whole assembly may then be fitted to the asset. At other times, it may be possible to begin assembly at the asset connection end and build the adaptors up from that.

Ensure no threads are damaged by cross-threading or trapped debris during assembly.

Ensure the asset (valve) to which you are making a connection is turned off prior to beginning installation and whenever fitting or removing equipment.

4.7.1   Connecting to a boundary box / ATPLAS connection

The Hydrophone-2 has a male thread of 1.5-inch BSPP, and is designed to be fitted directly to an ATPLAS / Boundary box with a female thread of 1.5-inch BSPP.

The Hydrophone-2 should be prepared for use (as per section 4.6) prior to fitting.

No adaptors are usually required, but an extension device to raise any existing water meter connection is available from HWM (if required).

The riser device also permits the one-way valve to stay in place.

When fitting Hydrophone-2:

Remove any debris from the boundary box and ensure it is clean.

Close the water valve and then remove any existing apparatus from the connection point.

Gently open the valve to flush out dirt and debris. Close the valve and inspect for cleanliness.

The Hydrophone-2 may then be fitted to the Boundary Box, tightening by hand initially. If using the Hydrophone 2 installation tool, be sure not to over-tighten as this could damage the boundary-box thread.

4.7.2 Connecting to a London Round Thread connection

The Hydrophone-2 has a male thread of 1.5-inch BSPP. HWM can supply a single-stage adapter to convert the Hydrophone-2 thread to 2.5-inch female London Round Thread.

If using the Hydrophone 2 with the London Round Thread adaptor, the Hydrophone 2, it must be first prepared (as per section 4.6).

The adapter can be pre-assembled to the Hydrophone-2 prior to use. Ensure no cross-thread damage occurs when connecting the two items together. It should first be fitted hand tight. Then tighten by a further 1/4-turn using 60mm and 50mm spanners on the flats.

DO NOT attempt to seal the threads between the Hydrophone sensor and the London round thread adaptor with PTFE tape or any other sealing material. The seal is made by the O-ring of the Hydrophone 2.

When fitting Hydrophone-2:

Remove any debris from around the valve connection and ensure it is clean.

Gently open the valve to flush out dirt and debris. Close the valve and inspect for cleanliness.

The hydrophone assembly can now be screwed onto the valve connection.
Ensure no cross-thread damage occurs when connecting the two items together.

The assembly should be hand tight initially.
Then use two the Hydrophone 2 installation tool to complete the tightening process.

Be sure not to over-tighten as this could make disassembly difficult.

4.7.3   Connecting to other types of valve connection

Globally, there are many other types of connection standards for equipment connection to the water pipe network. They are too numerous to mention here. Some countries may have many connection types in use.

For connection to other types of valve connection, follow the guidelines given in section 4.7, as appropriate.

4.8 BLEEDING THE HYDROPHONE

The Hydrophone 2 should be in direct contact with water and no local leaks should exist at the installation site ; the noise from local leaks can prevent the detection of leaks further into the pipe network.

Remove trapped air by attaching a hose (with tap) to the bleed valve of Hydrophone 2.
(HWM can supply a suitable re-usable bleed kit if required).

Ensure the tap is facing away from the equipment and that any water discharged will not cause damage to any other equipment or injury. Water should be discharged to an area away from the chamber so as to not cause flooding.

Slightly open the valve of the hydrant to allow water to pass into the Hydrophone chamber. Then open the tap of the bleed kit to allow water to flow and for any trapped air to escape.

Close the tap of the bleed kit once a steady stream of water (with no air bubbles) is present ; this indicates the air is completely expelled.

Once complete, the hose connecting the bleed valve to the Hydrophone 2 can be removed using the Quick Release connector. Then fit the quick release valve protector cap.

(Water must be safely discharged to a safe area)

Open Hydrant valve fully to allow water into the hydrophone. A fully open hydrant valve will give the best noise transmission to the Hydrophone.

4.9 (OPTION) USING HYDROPHONE AS AN ACCESS POINT FOR OTHER SENSORS

After the Hydrophone 2 has been bled, the attachment point for the bleed valve can be used as an access point to the water column for connection of other sensors (e.g., pressure sensors).

Connect the sensor to the Quick release connector using the appropriate fittings and connection hoses.

Bleed any hoses being used and cover them with an insulating material prior to leaving the installation site.

4.10 REMOVING THE HYDROPHONE 2 FROM AN ASSET

If it is required to remove the Hydrophone 2 from an asset, the following steps should be followed:

Ensure the valve is turned off before removing or fitting any equipment.

Ensure the surface of any apparatus that will replace the hydrophone (water meter, hydrant cover, etc) is suitably clean and sterile.

If flooded, drain the access chamber using a pump.

Clear any debris from the chamber, allowing good access to the Hydrophone and the asset.

Remove the Hydrophone 2 and any adaptors from the asset connection.
Keep them in a safe place so as to not get damaged and also where they can be kept clean.

Gently open the valve to flush out any dirt and debris. Close the valve and inspect for cleanliness.
Apply silicon grease onto the thread of the apparatus (hydrant cover / water meter, etc) that is to be replace the Hydrophone 2. Then fit it to the asset, ensuring threads are not damaged. Tighten as appropriate for the attached equipment.

The Hydrophone 2 should be cleaned, disassembled from any adaptors, and re-packed into its original container or carry-case. It should be made hygienically clean prior to its next use.

5   CONNECTING THE HYDROPHONE 2 TO YOUR LOGGER

(For connection of hydrophone to a correlator device, refer to the correlator user-guide).

5.1   DURING NORMAL USE

During normal use, the Hydrophone 2 will be connected to the logger by a 4-pin cable (e.g., part number CABA2715), shown below.

(To logger)

(To Hydrophone-2)

One connector has pins ; connect this to the Hydrophone 2, as shown opposite.

One connector has sockets ; connect this to the logger.

The logger connection will be labelled "LNS" or "LNS & Comms", (or similar) ; Refer to your logger user-guide any connector identification label on the logger.

All connectors should be kept dry and free of dirt and debris.

When attaching the cable, ensure the connector is correctly closed (twist to seal); It will then become a waterproof connection.

Note: The connector for the hydrophone may be shared with other uses. (e.g., Communications to programming tool. See section 5.2).

5.2   DURING PROGRAMMING

When programming the logger, the PC requires a programming cable. These can take various forms (a wired connection to the logger or an optical interface).

For some loggers, the use of Hydrophone-2 provides no complications ; the standard programming interface is used. However, for certain loggers, the Hydrophone-2 shares the same logger connector as the programming cable ; An additional cable (Y-adaptor) is required. The Y-adapter cable split the logger connector into 2 paths (logger to Hydrophone ; logger to USB communications interface).

The connection path is shown below:

To PC USB port

When using IDT, make a temporary
connection outside of the chamber
(to help keep connectors clean).

To Logger connector
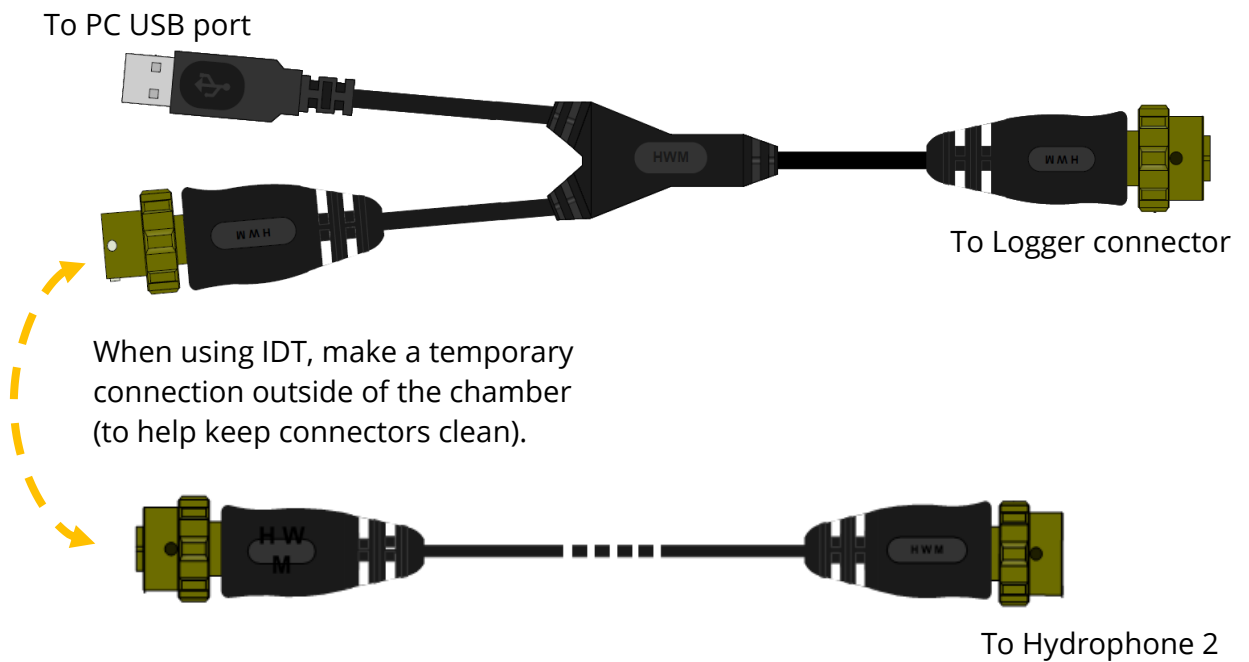
To Hydrophone 2

Refer to section 2.3.3 for details of whether the Y-adapter cable is required to
communicate with your logger family.

Once any programming and tests have been completed, remove the temporary Y-cable
and re-attach the Hydrophone-2 to the logger with the regular cable.

6 COMMUNICATING WITH THE LOGGER

To communicate with the logger (for local programming and test purposes), a PC is required, along with a HWM software utility called "**I**nstallation and **D**iagnostic **T**ool", or more commonly known as IDT (PC version).

Note: There is another version of IDT, the IDT (mobile app version).
        The app version of IDT is not used for loggers that have Hydrophone 2.

6.1 INSTALLING IDT (PC VERSION)

IDT (PC version) and its user-guide can be downloaded from the HWM Customer Support website, or from the following webpage:

https://www.hwmglobal.com/idt-support/

(Note: The user has to be registered by HWM and have a password to gain access).

Refer to the IDT User-guide for information on how to install and use the tool.

IDT can be set to different operational user-level "views" (which set the user-interface and available options). The "basic" or "advanced" view is sufficient for checking the setup and the test of the logger for Hydrophone 2.

6.2 COMMUNICATING WITH THE LOGGER

6.2.1 Connecting the comms cable / interface

To communicate with the unit a communications cable is required. Refer to the logger user guide and also to section 5.2 for further details.

Once you have installed the IDT, launch it. Then connect your PC to the logger's Comms interface; use a direct connection or the Y-cable, as appropriate; the Hydrophone-2 should continue to be connected to the logger whilst undertaking programming and test.

There will be a short delay before the PC recognises the connection of the logger; This is normal. If your PC has sound enabled, you will hear a sound when the logger connects.

Note: The first time you connect your PermaNet+ to a new USB port, Windows will
        configure the driver; Wait until this process is completed before proceeding.

The communications circuit of the logger is normally on standby, to preserve the unit's battery. Communication remains open for around 600s after it was last used. The link then goes back into standby. If this happens, unplug the USB cable for a few seconds then re-connect it.

6.2.2 Loading Logger settings into IDT (PC)

Click 'Read Device'.
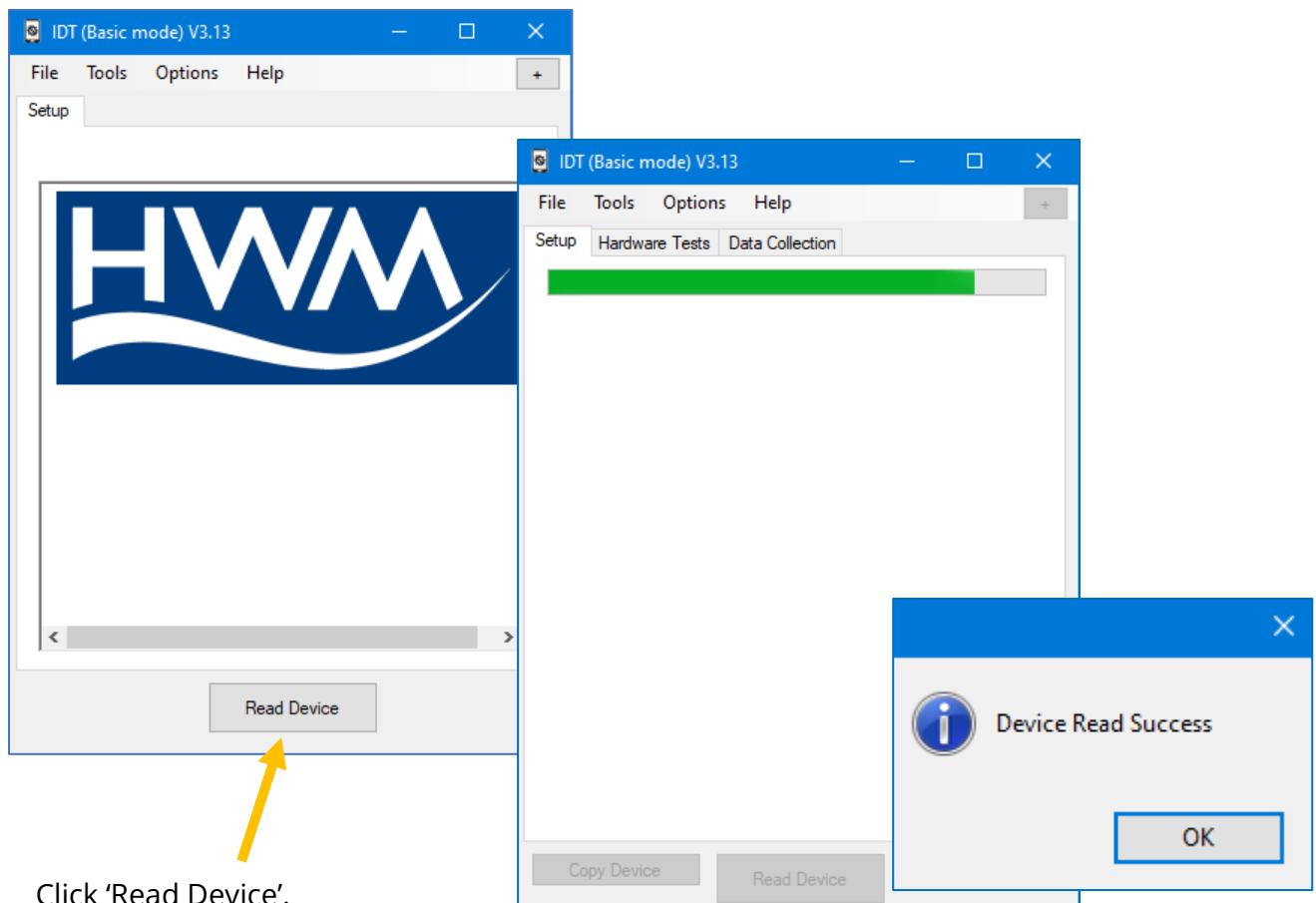
A progress bar will show across the top of the page. When completed, an information box will appear stating 'Device Read Success'. Click "OK" to clear the box.

The IDT-PC program has now read a copy of the unit's program (settings) into the "current program" memory area.

The settings can be changed within IDT but note that the unit itself is not updated with any of the program changes unless the user later saves the settings stored in IDT back into the logger by clicking on the "Setup Device" button.
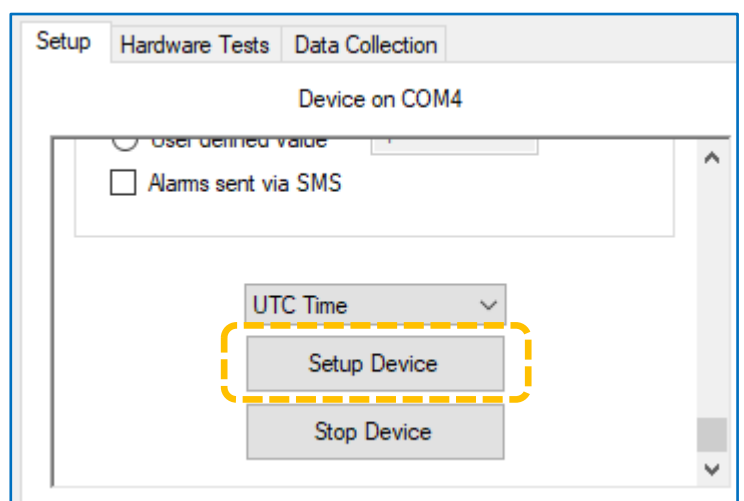
Note: The logger will usually have settings pre-programmed by the factory prior to shipping. However, **the installer has responsibility** for confirming the

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settings are appropriate for use at the installed site.
If you have specific requirements this can be discussed with your HWM sales representative at the time of ordering the loggers.

Before proceeding with setup, confirm the logger is set to use local time. Also check that the logging status is set to "Recording". (Refer to the IDT guide for guidance).

Note: Please refer to the IDT (PC version) user-guide.
The IDT user-guide is written primarily for a multi-purpose data logger, however many of the IDT functions and settings are common to your logger device. Where this is so, they will only be mentioned briefly in this guide.

The logger can operate in several modes (see section 3.1.5).
For certain modes it operates in a similar way to a general-purpose data logger, whilst in other mode it may operate using a specialised leak determination program. This user-guide will provide details of the program operation in each mode and the relevant additional settings for it.

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7 CONFIGURING THE LOGGER

7.1 CHECK / SETUP OF CHANNELS FOR USE WITH HYDROPHONE

7.1.1 Check of existing settings / adjustment

When shipped from the factory, the logger will usually have some pre-configured (or partially pre-configured) channels, including those required to generate data for the hydrophone sensor. If this is not the case, the channels must be added in order to be able to drive the sensor to obtain data.

Note: The channels may be partially set up

to ensure that the channel numbering of the data streams will marry-up with those that have been set up for the logger on the DataGate server.

The channel types required for Hydrophone 2 are:

- LNS-Leak
- LNS-Level
- LNS-Spread

To check if the channels already exist:

After reading the logger configuration, select the Setup tab and locate the "Logging Channels" panel; this shows any channels that already have some configuration for data-logging.

If channels for the Hydrophone have already been created, they will be listed (along with any other channels). A summary of its settings is also shown.

Make a note of the channel numbers assigned for each channel type, in case it is needed later (e.g., For the programming of alarms).

For each channel, tap on the 'setup cog' button to check the settings.

2	LNSLeak, Multiplier: 1.0, Ave	⚙
3	LNSLevel, Multiplier: 1.0, Ave	⚙
4	LNSSprd, Multiplier: 1.0, Ave	⚙
		✚

An example of *incomplete settings* is shown opposite:

(e.g., Some fields are missing).

If any settings are incomplete, the missing settings should be completed.

Logging Channel Setup

Channel 2

Input Sensor	LNSLeak ⌄
Sensor Type	⌄
Recording Unit	⌄
Logging Mode	Average ⌄

Accept   Cancel
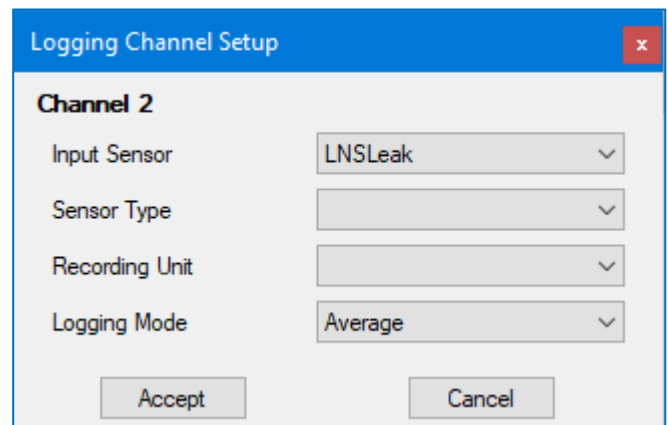
For Daily leak determination mode, set the LNS-Leak channel up as shown opposite.

For Trunk Main mode, set the channel up in an identical manner.

Tap on the Accept button when complete.

Logging Channel Setup

Channel 2

Input Sensor	LNSLeak ⌄
Sensor Type	Leak ⌄
Recording Unit	state ⌄
Logging Mode	Spot ⌄

Accept   Cancel
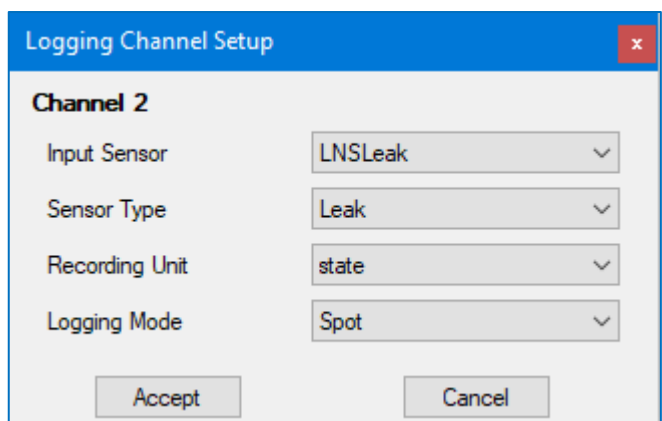
For Daily leak determination mode, set the LNS-Level channel up as shown opposite.

For Trunk Main mode, set the channel up in a similar manner, but with a logging mode of your choice (minimum, average, maximum).

Tap on the Accept button when complete.

Logging Channel Setup

Channel 3

Input Sensor	LNSLevel ⌄
Sensor Type	Noise ⌄
Recording Unit	dB ⌄
Logging Mode	Spot ⌄

Accept   Cancel
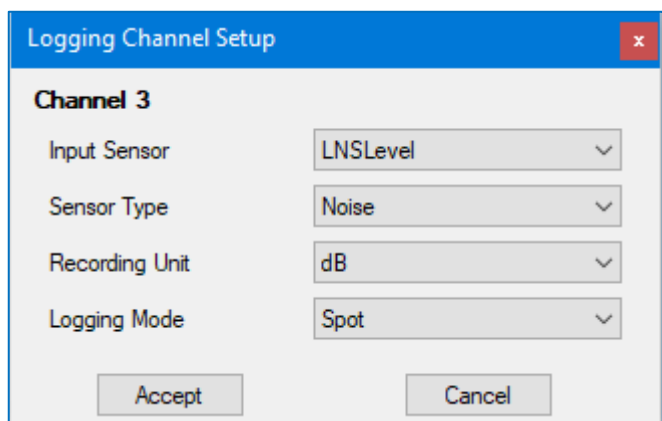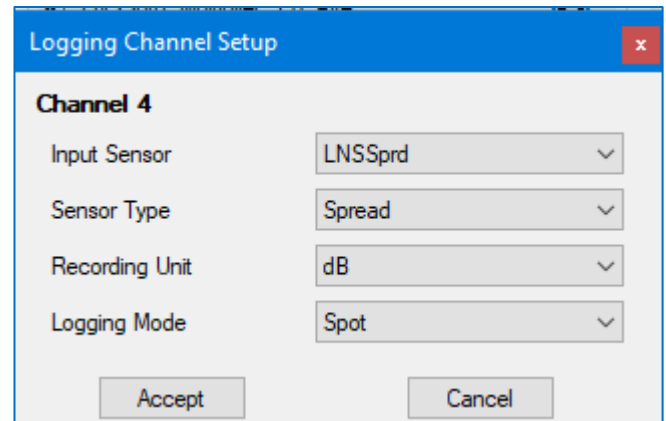
For Daily leak determination mode, set the LNS-Sprd channel up as shown opposite.

For Trunk Main mode, set the channel up in an identical manner.

Tap on the Accept button when complete.

Note: For the Daily leak determination mode, no datapoints will be produced at the logging rate, as the regular logging activity becomes deactivated by other settings (see section 7.2) ; the logger's use of the above settings is to some degree ignored.

Note: For the Trunk Main leak determination mode, datapoints will be produced at the logging rate, as normal. The settings for leak determination (see section 7.4) to some degree ignore the above settings, which are used for logging purposes only.

7.1.2   Setup of non-existing channels

If the channels (shown opposite) do not exist, they need to be added by tapping on the ' + ' button.

(Refer to the IDT user guide for details on adding a channel to a logger).

Add the channels such that the resultant setup is as detailed in section 7.1.1.

7.1.3 Hydrophone-2 functional tests

The Hydrophone-2 unit can be tested using the IDT tool.

Save any existing changes to the logger setup prior to test.

Check the Hydrophone-2 is connected prior to starting the test.

Select the 'Hardware Test' tab.

Confirm the Hydrophone-2 channel appears amongst the list of result fields ; It will appear as a 'Leak noise sensor'.

Click on the 'Start Test' button.
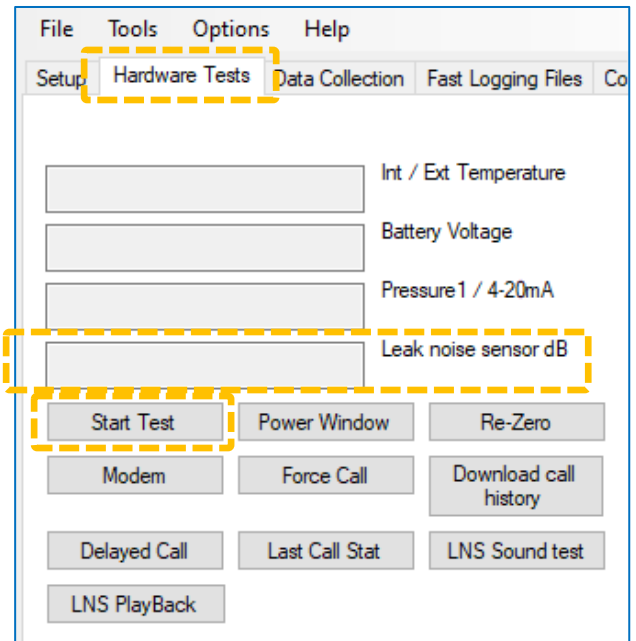
The Hydrophone-2 sound level (ambient noise) is measured by the logger every few seconds and is shown in the Leak noise sensor results window.

When installed into the water column, the sound level value represents the ambient sound in the pipe network.

If a pre-installation test is being made, the sound level value represents the ambient sound in air. Lightly scratching the metal side of the Hydrophone-2 will cause the measured level to change, thus confirming it is operating OK.

Keep test time to a minimum to preserve the logger battery life. When you are satisfied that the unit is operating OK, click on the 'Stop in' button to halt the test.
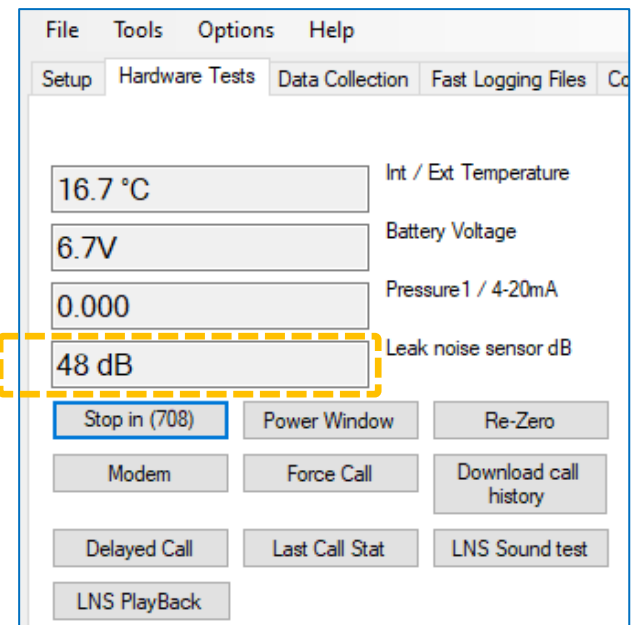
Further confirmation of the Hydrophone-2 audio can be made by making a sound recording from the Hydrophone-2. When completed, the sound recording can be uploaded to the PC and played back (through headphones connected to the PC, etc).

To start producing the sound recording, click the 'LNS sound test' button.

... Initially a count-down will be shown on the button.

... then it will show as 'recording'.

When the recording is complete, click on the 'LNS Playback' button.
IDT will first upload the audio to the PC (which takes approx. 30 seconds).
IDT will then play the audio back through the PC speakers (or a pair of headphones, if attached to the PC).
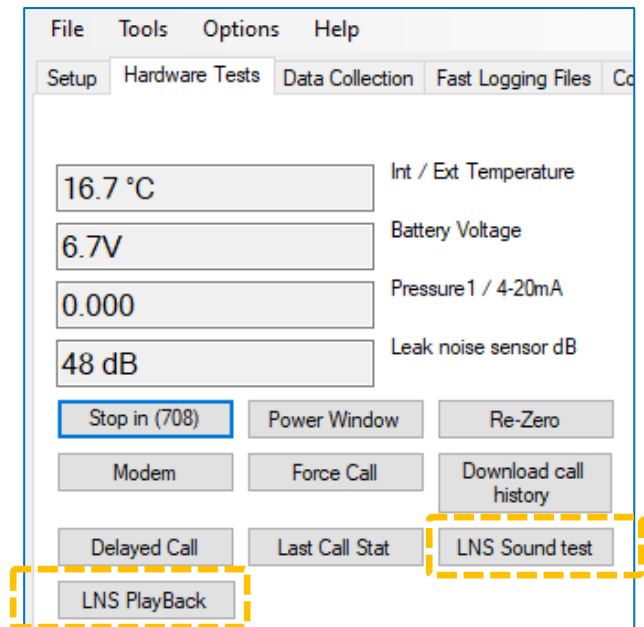
7.2 CONFIGURING LEAK DETECTION (SELECTING THE EVALUATION MODE)

The logger interface must first be set up to drive the Hydrophone sensor to obtain audio samples, as detailed in section 7.1

Note: The IDT display is adaptive in behaviour and shows information and controls which change depending on previous selections / de-selections.

To configure the logger, first select the Setup tab in IDT.

The Setup tab is divided into panels of related settings.

The controls for the leak determination program cycle, and other relevant settings are found in the Logging Parameters" panel.
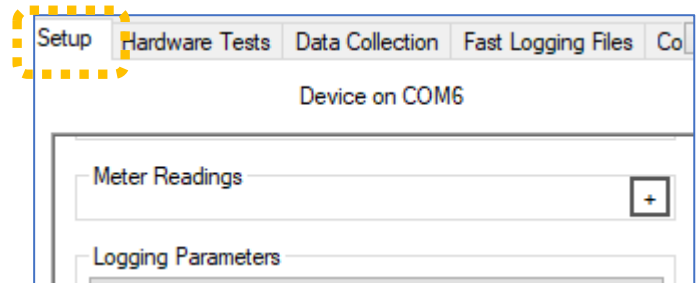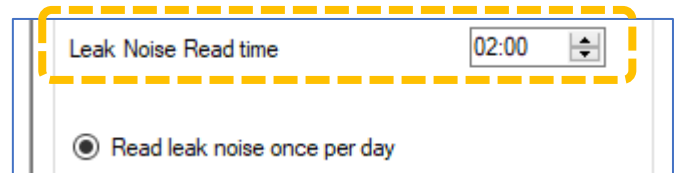
The leak evaluation mode is selected using the 'radio button' style controls, shown opposite.
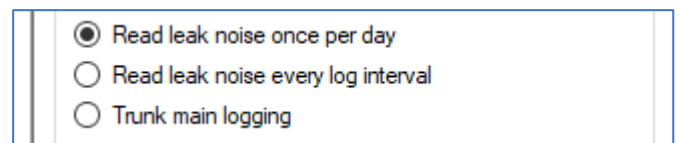
- For the logger to use daily leak evaluation mode,
  select "Read leak noise once a day".
  The sensor is excluded from being activated at the sample rate (which is used for most sensors).

- For the logger to use Trunk Main leak evaluation mode,
  select "Trunk main logging".
  The sensor is included amongst the sensors that are activated at the sample rate.

- **Do not** select the "Read leak noise every log interval" setting.
  This setting the is for HWM use only, and never for general use.
  (If set, the logger will run the daily leak noise program many times a day and will soon exhaust the battery).

7.3 CONFIGURING LEAK DETECTION (DAILY EVALUATION MODE)

With the 'Read Leak noise once a day' selection set, a "Leak Noise Read Time" field becomes visible.

The "Leak Noise Read time" field controls the time (using a 24-hour clock) when the leak determination program is to be run with the Hydrophone.

It is usual to set this to a time when the water network has minimal noise, such as when it is in minimal use (usually in the early hours of the morning).
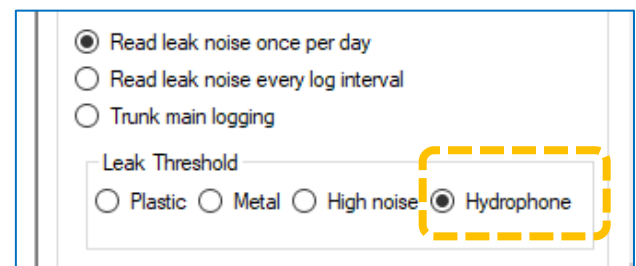
Note: The entire system should have timings set to work in a co-ordinated manner. Leak determination by the logger should occur close to the optimum (quiet) evaluation time. Sufficient time should however be allowed for any confirmation checks by the unit, which must occur before data is sent into the server.
The server, in turn, should have received data from the loggers prior to the typical start of the working day, so that a recent evaluation of the leak status of each of the sites being monitored by the fleet of loggers is available for users (of the PermaNET+ data viewer) early in the day.

One section of the Logging Parameters panel is a "Leak Threshold" selection.
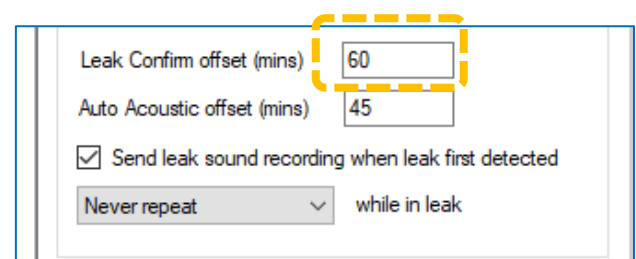
This is a sensitivity control which determines which threshold is being used as the judgement of a leak / no-leak condition during leak determination.

For use with the Hydrophone 2, select the 'hydrophone' setting.
(The other selections are for use with a different type of leak noise sensor).

To avoid giving false leak indications, the leak detection program is run a second time, which produces the final judgement. This confirmation run avoids leak indications being generated for temporary noises within the environments (engine noises from a parked lorry, etc).

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The time-delay for the confirmation run is set in the field shown. As well as allowing the environmental noise to disappear, a short break will also give some time for the battery to recover.

The "send leak sound recording when leak first detected" control will (when set) cause the PermaNet+ unit to make a short recording of the pipe noise if it judges that a new leak is present.

The recording lasts typically for 10 seconds.

The Auto Acoustic offset control sets the time delay (after the confirmation run) for when the audio recording (if enabled) is to be made.

There are options regarding repeating the audio recording whilst the logger continues to show a leak condition.

The audio recording(s) are stored in the logger and will be uploaded to the server at next logger call-in. A user can then listen to the noise (played back from the server) to form an opinion as to whether it sounds like a leak.

For daily leak determination, *a single datapoint is produced each day* for the following channels, each being associated with the Hydrophone-2 leak-noise-sensor.

- Level
- Spread
- Leak indication (judgement)

(The selections of Logging mode, etc, as detailed in section 7.1.1, for producing sensor datapoints are disregarded and over-ridden).

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the "Setup Device" button in IDT.
(This is located towards the bottom of the Setup tab).

7.4 CONFIGURING LEAK DETECTION (TRUNK MODE)

With the 'Trunk main logging' selection set, a "Time sync on alarm" control also becomes visible (refer to section 7.4.3).

In addition, the Leak Threshold changes to be able to set a numeric value (no longer a limited choice based on a material or sensor selection).

The Trunk Main mode runs frequently, and therefore requires the setup of the timing parameters.
(Setup is identical to that of a standard HWM logger that logs sensor measurements; refer to the IDT user guide).

For Trunk Main mode, the selector should be set to "log data at specified time interval", as shown.

e.g., Here the sample interval is 30 seconds, and the log interval is 15 minutes.
The logger listens to a short (approx. 150mS) sample of the audio from the Hydrophone-2 every 30 seconds and calculates the sound power level.
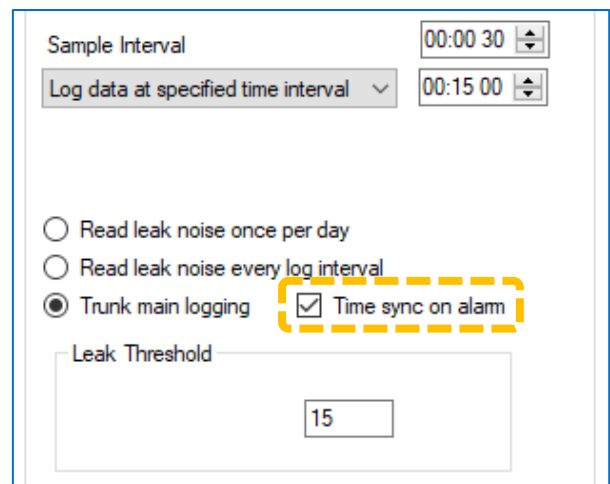A set of data (the results of the measurement samples) are temporarily stored in order to produce datapoints (at the log data time intervals).

For Trunk Mode leak determination, a continuous stream of datapoints are produced for the following channels, each being associated with the Hydrophone-2 leak-noise-sensor.

- Level
  The channel can be set to a logging mode of minimum, average, or maximum ; Logged datapoints will conform to the selection.
  For the purpose of leak determination, the channel setting is disregarded, and the Average value of the set of samples is used.

- Spread
  The channel must use a logging mode of spot.
  For the purpose of leak determination (and the production of Datapoint values), the spread is always evaluated as the (maximum level – minimum level) from the set of available samples.

- Leak indication (judgement)
  The channel must use a logging mode of spot.
  For the purpose of leak determination (and the production of Datapoint values), the leak indication is always judged using the following:
  Is (Level – Spread) greater than Leak Threshold?

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The purpose of trunk main logging is to provide as early alarm as possible in the event of a burst in order to reduce the impact on consumers and the massive loss of water and potential flooding that can occur. This requires the logger to be set up with alarm conditions. When the alarm condition is met, the logger generates an alarm message for sending to the DataGate server. The server then distributes the alarm to any interested parties.

7.4.1   Use of the Leak Threshold for triggering Alarms

One method of producing an alarm is to use the LNS-Leak indication.

The leak indication is based on the difference between level and spread values, this being compared with the set Threshold value.

It is recommended that before an actual alarm is programmed into the logger, it is run at the site for a while and that the leak threshold (initially set low) is slowly adjusted (higher) to a point where the LNS-Leak indication is not showing any false indications of a leak being present.

Once the correct leak threshold value for the site has been found, then set an Upper-level alarm (as shown opposite), monitoring the LNS-Leak channel. This will send an alert if the Leak Threshold is crossed.

If you still get false alarms, you can adjust the sensitivity by changing the Persistence setting. (e.g., Set 6 out of 9 to only set the alarm if 6 thresholds out of 9 consecutive ones are crossed). However, use of persistence will increase the time between a suspected burst and the alarm being triggered so careful choice of logger interval vs persistence should be made.

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the "Setup Device" button in IDT.
(This is located towards the bottom of the Setup tab).
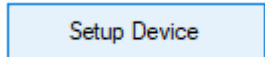
7.4.2 Use of level (profile alarm) for triggering Alarms

One method of producing an alarm is to use the LNS-Level value.

This is based on the assumption that a leak caused by a burst mains will raise the noise level produced from the pipe to a higher-than-normal level.

The noise from the pipe network should be studied for some time to determine if it does follow some regular pattern of behaviour, with predictable noise levels. If not, this method is unsuitable.

A profile alarm can then be created, monitoring the LNS-Noise channel, with an upper threshold being set at a level above what is normally expected at various times of the day.

(For details of how to set up a Profile Alarm, please refer to the user guide for IDT).

It may be useful to add an additional channel (set to LNS-Level, maximum) in order to make an assessment of the noise values that the pipe network produces ; this will include the maximum from all the data sampled, some of which could otherwise be missed.

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the "Setup Device" button in IDT.
(This is located towards the bottom of the Setup tab).
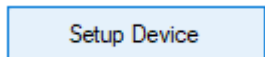
7.4.3   Use of an alarm to trigger an audio recording

When in Trunk Main mode, an alarm trigger also has to set up to start the process of informing interested parties that there is a potential issue (leak). (See sections 7.4.1 and 7.4.2).

If the "Time sync on alarm" is selected, additional activities are put into motion within the logger itself whenever any alarm is triggered.

- The logger is set to make a call-in which now will include the additional task of very accurately synchronising the logger's clock with the network.
- The logger is set to make an audio recording on the next available log boundary (15 minutes later in the above example).

The purpose of the time-sync is to give the server the option of using the sound files of two or more loggers (if they simultaneously detect the leak) for correlation purposes, to try to locate the leak position.

The logger uploads the audio file to the server at the next call-in time.

7.5   CONFIGURING LEAK DETECTION (ALONGSIDE REGULAR LOGGING)

The loggers can carry out leak detection activities (in both Daily leak determination and Trunk Mode leak determination) whilst simultaneously running the tasks required for the logging the data from any other sensors.

e.g.,   If an interface and sensor for monitoring water pressure, this can also be set up for regular logging activities.

(For guidance on the setup of other interfaces, please refer to the IDT user-guide).

7.6 Configuring Audio filters for Hydrophone-2

The Hydrophone-2 (and logger) will pick up a wide range of sound frequencies from the water column. However, not all are desirable for the purpose of leak detection. The noises could include mains hum, water pumps, or other temporary noise sources, such as traffic.

The logger has a comprehensive set of filters available for use in order to discard some of the unwanted noises and to focus its attention on noises that could be leaks.

The settings can be found in the 'LNS Filter Settings' panel.

There are 2 selectors.

The top selector, labelled 'Mains Notch Filter', is the main control; it decides how the lower filter, labelled 'Leak determination Filter' is to be applied (or indeed, switched off).
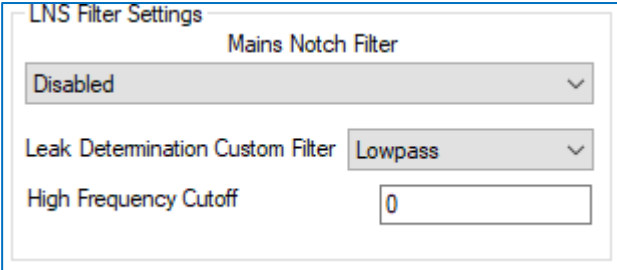
The following filter types are available:

- Standard Filter.
  This is a wide-band mains frequencies suppression filter.
- 50Hz Notch.
  This is a narrow-band mains frequency suppression filter, tailored to 50Hz mains.
- 60Hz Notch.
  This is a narrow-band mains frequency suppression filter, tailored to 60Hz mains.
- Low-pass can be used to reject high frequencies.
- High-pass can be used to reject low frequencies.
- Band-pass can be used to reject both high and low frequencies, but accept mid-frequencies.
- Notch can be used to reject a specific band of frequencies, but allow other to pass through.

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The Low-pass filter, when selected, has an appropriate field to set the cut-off frequency.
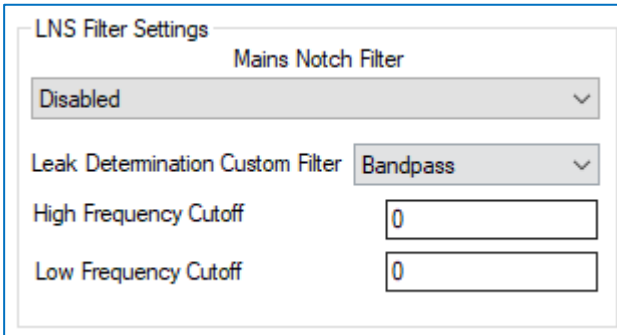
LNS Filter Settings
Mains Notch Filter
Disabled
Leak Determination Custom Filter | Lowpass
High Frequency Cutoff | 0

The High-pass filter, when selected, has an appropriate field to set the cut-off frequency.

LNS Filter Settings
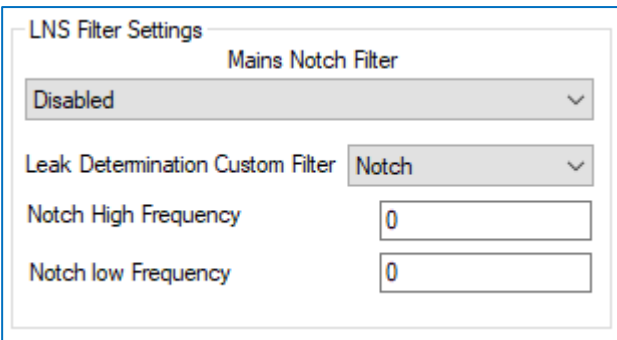Mains Notch Filter
Disabled
Leak Determination Custom Filter | Highpass
Low Frequency Cutoff | 0

The Band-pass filter, when selected, has appropriate fields to set the lower and upper cut-off frequencies.

LNS Filter Settings
Mains Notch Filter
Disabled
Leak Determination Custom Filter | Bandpass
High Frequency Cutoff | 0
Low Frequency Cutoff | 0
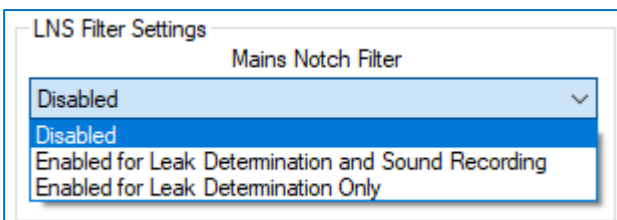
The Notch filter, when selected, has appropriate fields to set the lower and upper cut-off frequencies.

LNS Filter Settings
Mains Notch Filter
Disabled
Leak Determination Custom Filter | Notch
Notch High Frequency | 0
Notch low Frequency | 0

The 'Mains Notch Filter' selector can either:

- Disable the selected filter.
- Apply it for leak determination purposes only.
- Apply it for both leak determination and also sound recording purposes.

LNS Filter Settings
Mains Notch Filter
Disabled
Disabled
Enabled for Leak Determination and Sound Recording
Enabled for Leak Determination Only

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7.7 ADDITIONAL DATA FROM A 1-TIME PROGRAM - AQUALOGS

The "Manual Aqualog Recordings" control will (when set) cause the logger to produce Aqualog data.

Aqualog production is a temporary addition to the logger's regular task of leak determination.

When Aqualogs are enabled, IDT show another panel for the Aqualog settings.

An Aqualog produces data for a histogram of the noise levels that appear on the water network. More precisely, it can produce several sets of data for histograms, collected at different times.

The start time (and date) is selected using the "logging time" control; enter a date and time to commence.

The "Duration of each sample" sets the length of the Aqualog data collection cycle.

The "Time between samples" is the pause time before beginning the next Aqualog data collection cycle (if any are still pending for the current day)

The "Samples per day" sets the number of times the Aqualog data collection cycle should be run during each day.

The "Take readings for" control sets the number of days the daily cycle should be repeated.

When the Aqualog panel settings are complete, click the "Send Aqualog Settings" button. This will upload the temporary additional logging task to the unit. The Aqualog data will be uploaded to the server and can be viewed once the data has been produced and stored.

7.8 ADDITIONAL DATA FROM A 1-TIME PROGRAM – SOUND RECORDINGS

The "Manual Sound Recording" control will (when set) cause the logger to produce additional sound recordings.

The production of these sound recordings is a temporary addition to the logger's regular task of leak determination.

The recordings will be made independent of any leak judgement (i.e., whether a potential leak is detected or not).

When Manual Sound Recordings are enabled, IDT show another panel (Acoustic Logging) for the settings. This has controls for setting a temporary program cycle for obtaining the additional Sound recordings.

The start time (and date) is selected using the "Recording time" control; enter a date and time to commence.

The "Duration of sound log" sets the length of the audio recording.

The "Sound logs per day" sets the number of times the logger must make a sound recording during each day.

When the Acoustic Logging panel settings are complete, click the "Send Sound Settings" button.
This will upload the temporary additional logging task to the unit. The Sound recordings will be uploaded to the server and can be played back from the server once they have been produced and stored.

8 INSTALLATION

8.1 COMPLETING LOGGER INSTALLATION

Diagrams of typical installations of a logger with Hydrophone are shown (opposite and below).

The logger unit must be mounted in a suitable location where the Hydrophone attached can reach its intended installation point.

Ensure the antenna (not shown) can be mounted in a suitable location where the radio signal will be of sufficient strength to call into the cellular network.

Cables should be positioned so as to not cause any hazards. Do not allow any equipment to rest on cables or connectors as crush damage can result.

The logger should be installed in the orientation shown on its label (this way up / arrow indication) for optimum battery performance.

(Logger image is for illustration purposes only. Additional sensors may be in use but are not shown in the diagram).

Continue the installation of logger, antenna, and any additional sensors.

Complete any further setup and tests of the logger including a test of communications to the server (see logger user-guide). This will require the communications cable (and any Y-adaptor in use) to be left in place during this process.

Before leaving site, disconnect any Y-cable being used for communications purposes and then re-connect the Hydrophone to the logger using just the Hydrophone cable.

Ensure the connector is correctly seated, so it is water-tight.

8.2 INSTALLATION GUIDELINES

Every site installation is unique with various types of connections, positioning or environmental conditions possible, the following recommendations will assist in a reliable installation.

- Keep the equipment neatly arranged in chambers so that cables are not crushed.
- Where the antenna is held in place by a magnet, ensure the weight of any cables does not excessively load the magnet so as to detach it from the installed location.
- Do not allow any equipment to rest on the antenna connector as crush damage to the connector or antenna cable can result.
- Do not pull the logger, antenna, or any sensor by any cable as this can cause damage.
- Always ensure that the contact point for any magnets are free from dirt, so that the magnet makes a good contact.
- If fitting the Hydrophone to a hot water pipe, ensure the equipment does not exceed its specified maximum temperature rating.

9 VIEWING YOUR DATA

Each logger calls into a server, where its data can be stored. The data is linked to the site on which the logger is deployed. The server therefore stores the current status (and historic data) for an entire fleet of loggers, linked to the sites on which they are deployed.

Site data can be viewed with a viewing tool (usually a website, such as HWM DataView). Another viewing tool commonly used with loggers which use a Daily Leak Evaluation mode is the HWM PermaNETWeb website.

PermaNETWeb can display the status of *multiple* devices (sites) simultaneously, thus allowing the state of an area of a utility network to be easily visualised.

This can be shown as a "dashboard" graphical status (see opposite).
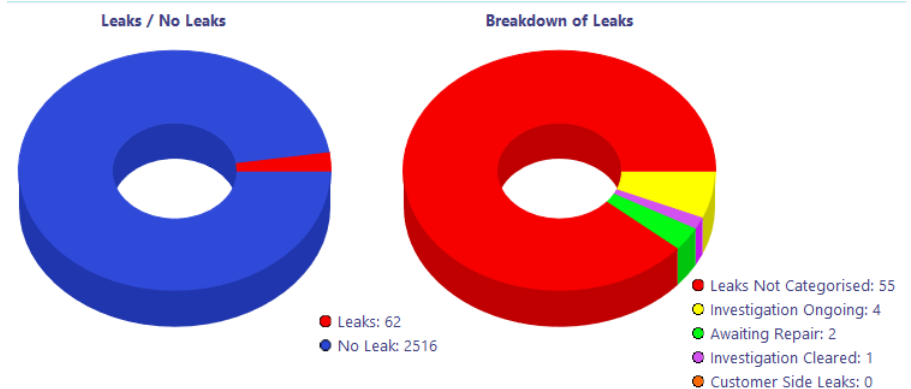
Alternatively, the state of an area of a utility network can be visualised by showing each site as a coloured dot or icon on a background map (or satellite view) and the current leak determination status for the site (or the logger call-in status); see below.
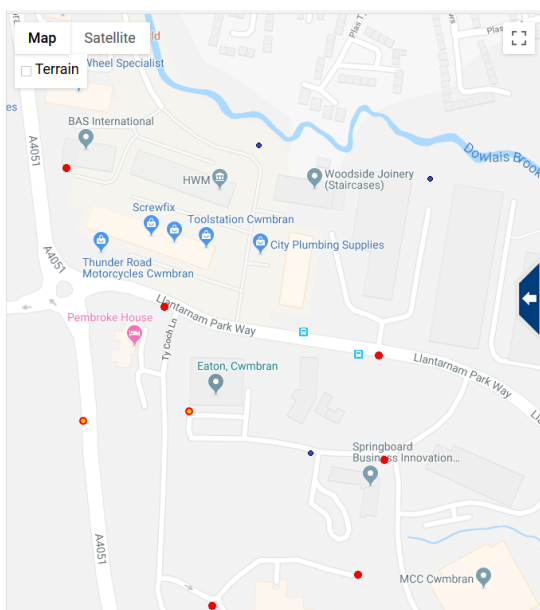
Refer to the appropriate manual or training provided for your viewing tool for further guidance.

# 10 INTERPRETATION OF LEAK DATA

The following illustrations of level and spread results are based on loggers that are set to make an extensive single daily evaluation. The concept will be similar for other logger algorithms (e.g., Trunk main), but some differences exist (not detailed here).

10.1 LEVEL AND SPREAD RESULTS (USING SINGLE DAILY EVALUATION)

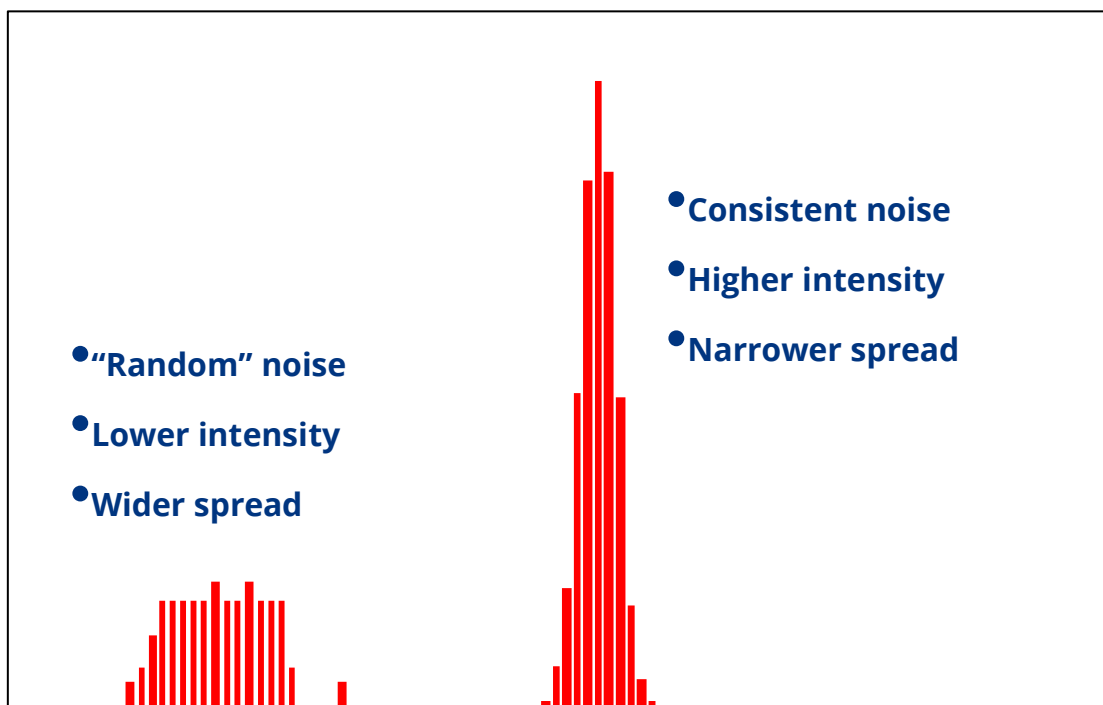The raw sound level is measured on a scale between 0dB and 99dB.

The signal **Level** (in decibels) is the point on the dB scale where there is a clearly identifiable peak.

The **Spread** is the width (number of dB values) that can be considered to be included within the over-all shape of the biggest peak.

Level = 48 Spread = 06

45 46 47 48 49 50 51 52 53 54 55 56 57 58 59
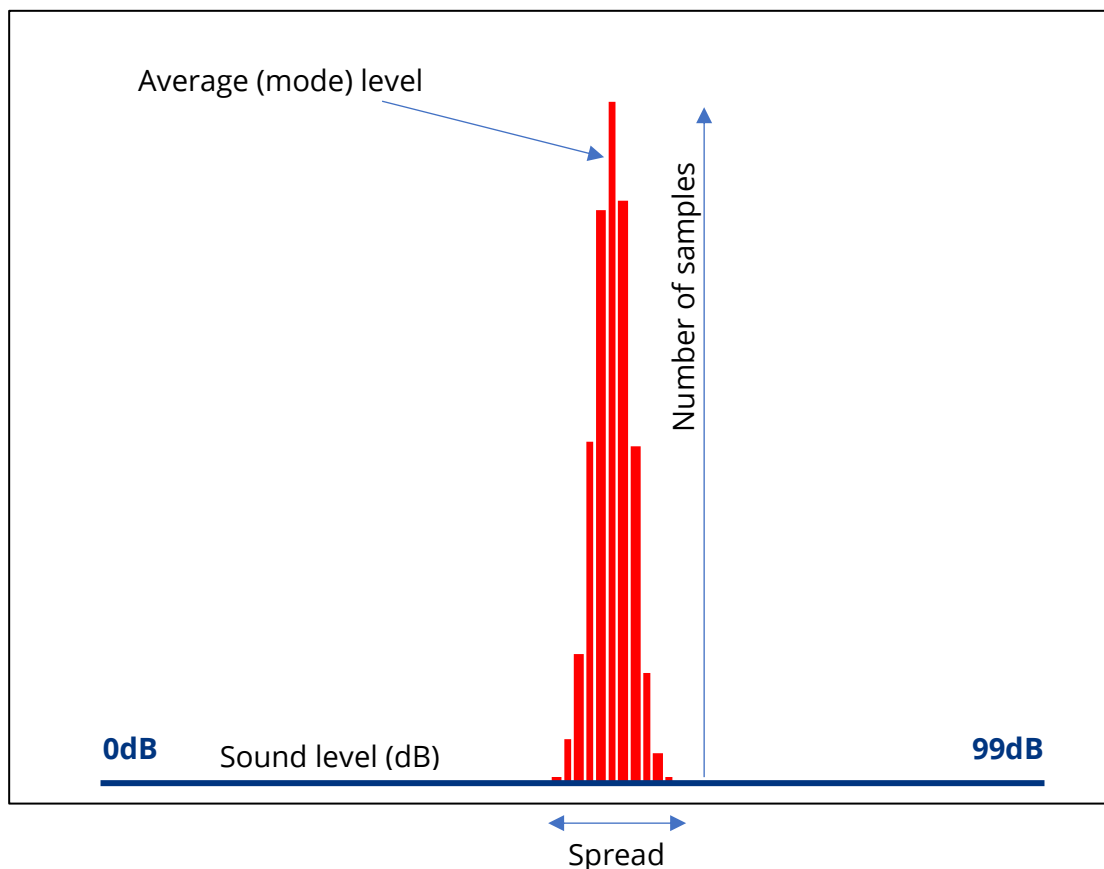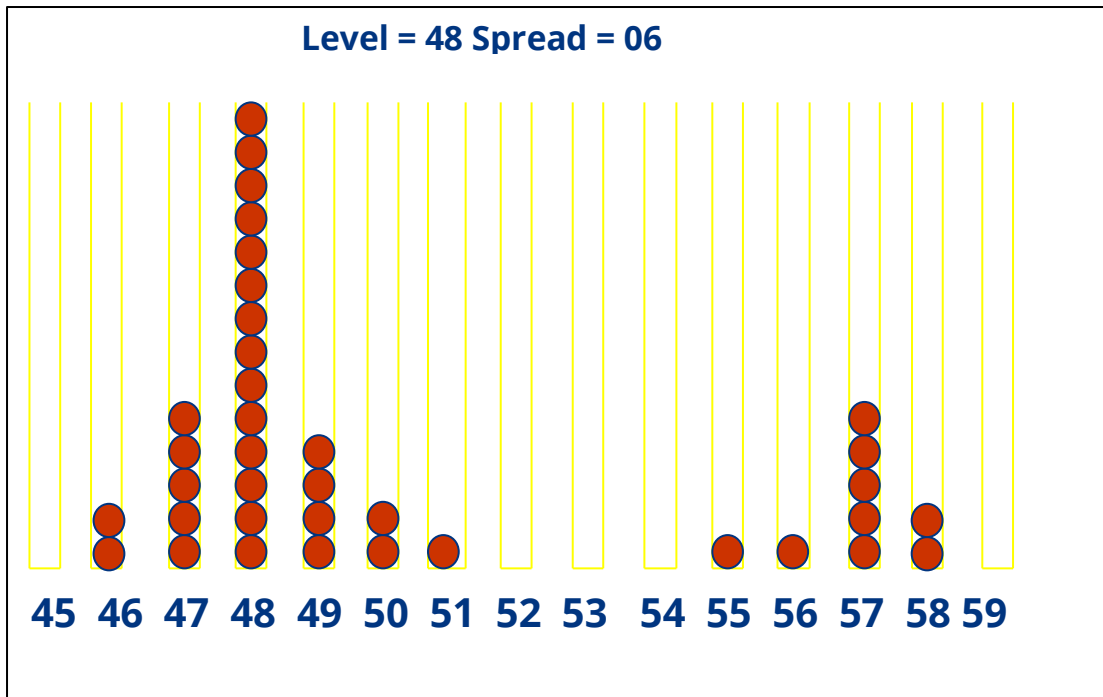
Each test will provide different results depending on the ambient noise conditions at any given deployment. A leak will be indicated by a consistent noise generated at a higher intensity than any random background noise, so the best indication of a leak is a high peak with a very narrow spread, see example on the right below. The noise on the left is a probably not a leak as it is low intensity and broad spread.

- "Random" noise
- Lower intensity
- Wider spread

- Consistent noise
- Higher intensity
- Narrower spread

10.2 Level and Spread results (using Tunk Mode)

The raw sound level is measured on a scale between 0dB and 99dB.

The algorithm for obtaining level and spread figures is less elaborate than the extensive daily leak evaluation method (see 10.1). This is due to the logger making frequent assessments. These have to be kept short in duration (to conserve battery use), which results in less data being used for each assessment.

The level and spread figures are produced as datapoints (at the log period) and are based on the audio power measurements that are produced (and temporarily stored) at the sample rate, in between log periods. The level used for leak evaluation purposes is taken as the average value, and spread is the difference between maximum and minimum value.

Leak judgements (datapoints) are made at the log rate. However, the judgement is not considered "final" as the alert of a leak involves the setting of a logger alarm. The alarm triggering conditions filters the stream of leak-judgement data, monitoring the raw leak indication until it becomes suitably stable; the alarm is triggered ; Interested parties are alerted to consider investigating the possible leak.

A leak will be indicated by a consistent noise generated at a higher intensity than the regular random background noise. When a leak occurs, the average sound level will increase, and that increase will be persistent, causing the alarm set to alert users to trigger.

10.3 AQUALOG / HISTOGRAM RESULTS - EXAMPLES

The following section discusses how to read Histograms.

Note: A standard histogram is amongst the data received from the logger once per day. An 'Aqualog' is the same as a 'Histogram' but is manually triggered and has customisable timings.
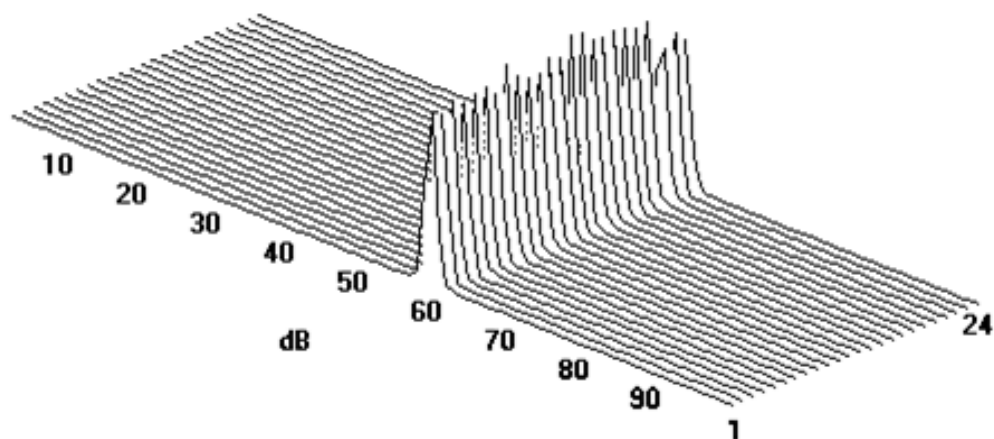
Examples:

In the below example of a 'good leak indication,' measured over 24 days there is an average **Spread** of 5dB and **Level** of 58dB at the peak.
This shows a high repeatability of the leak noise.
Average Level = 58
Average Spread = 5

In the below example of a 'poor leak indication' again measured over 24 days, there is an average Spread of 27dB and Level of 21dB at the peak. This shows a poor repeatability of the leak noise.
Average Level = 21
Average Spread = 27
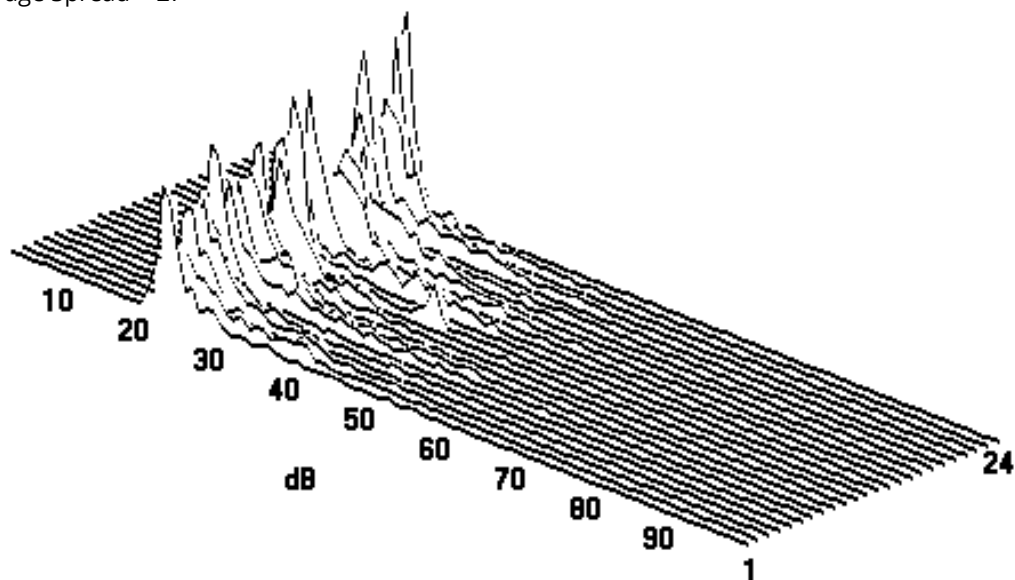
In the below set of examples the strongest leak indication is No 3 – a narrow spread (5dB) and a strong level (60dB).
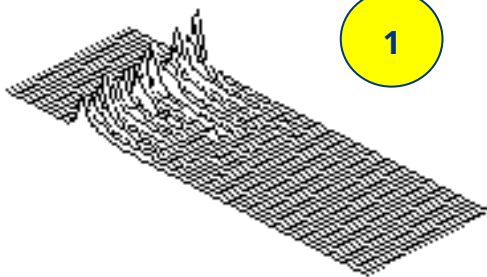
The others do not offer good indications of leaks:
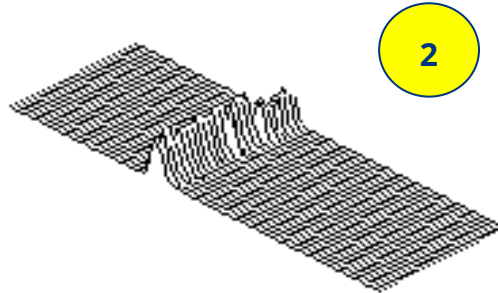
No 1 … Big spread / poorly defined peak,
No 2 … Good spread but poor peak,
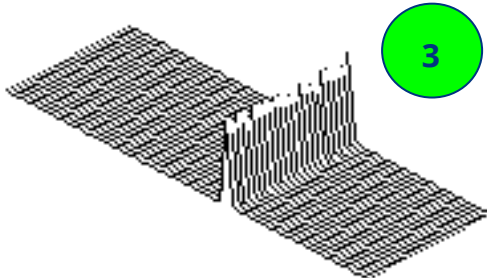No 4 … Big spread / inconsistent peak.

Average Level = 21
Spread = 27

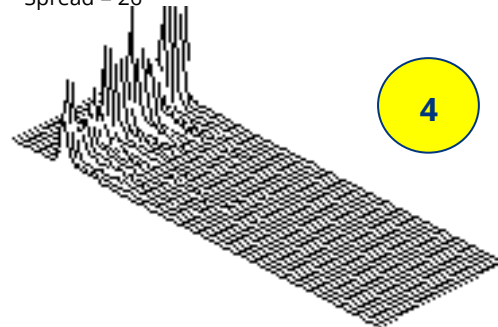Average Level = 24
Spread = 9

Average Level =60
Spread = 4
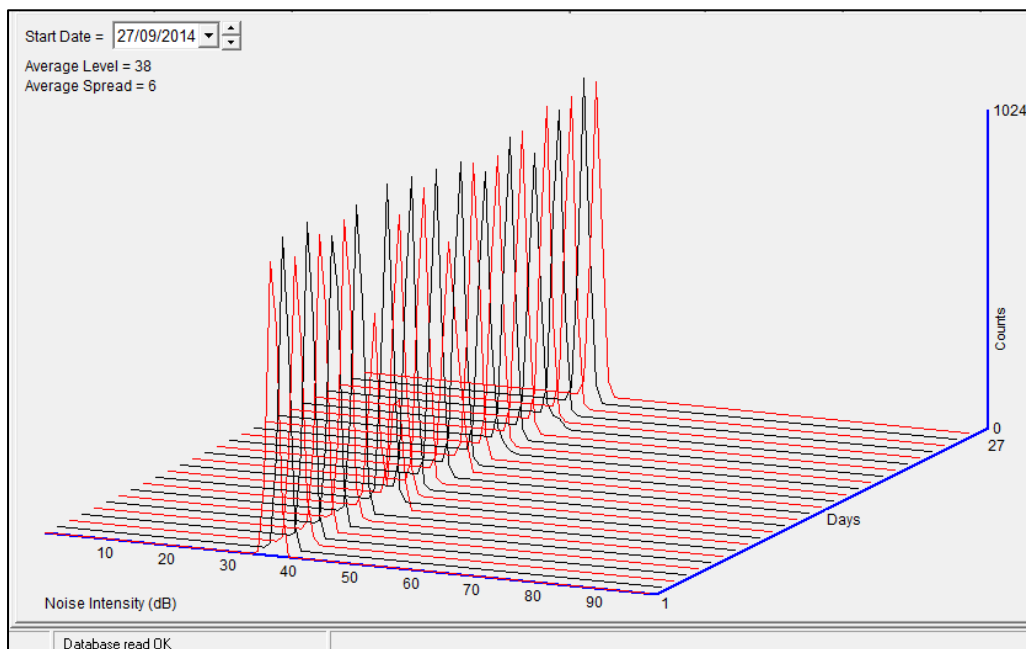

Average Level = 29
Spread = 26

In summary:

The best indication of a leak is with the highest consistent peak (noise) with the narrowest spread and the highest number of samples in it.

See below a typical PermaNet+ Aqualog screen shot showing a good example of a leak.

Note: Aqualogs and Histograms are not available on all loggers
(e.g. They are not provided on loggers operating in Trunk Main mode)

11 TROUBLESHOOTING

The data from the logger does not appear on the server:

- Check the settings for the SIM card to access the mobile data network.
- Ensure the logger uses the correct data destination URL and port-number for your server.
- Check call-in times have been set.
- Check antenna is attached and in an OK condition.
  Check signal quality and strength parameters are suitable. Re-locate the antenna, if required, or try an alternative type of antenna.
- Make a Call Test and confirm OK.
- Ensure your server is correctly configured to receive and present the data.
  The channel numbers used by the logger and the DataGate server must match.

12   MAINTENANCE, SERVICE AND REPAIR

Unauthorised servicing will void the warranty and any potential liability for HWM-Water Ltd.

Hydrophone 2 is a sealed unit and has no user-serviceable parts. Do not attempt to disassemble the unit since it may become damaged, which will not be covered by warranty.

12.1 REPLACEABLE PARTS

O-Rings and seals

- Check condition of any O-rings or other seals on the Hydrophone 2 or any supplied adaptors prior to use. Do not use if damaged.
- Only use replacement parts recommended and provided by HWM.

Adaptors

- Check condition of threads on any adaptors provided for use with Hydrophone. Do not use an adaptor or Hydrophone 2 with a damaged thread.
- Only use replacement parts recommended and provided by HWM.

Silicon Grease

- Only use replacement parts recommended and provided by HWM.

Hydrophone 2 Installation Tool

- Only use a replacement part provided by HWM.

Carry Case

- Contact your HWM representative to check for availability of a carry case for Hydrophone 2.

Cables

- Only use a replacement part provided by HWM.

12.2 RETURN OF PRODUCT FOR SERVICE OR REPAIR

When returning product for investigation or repair, be sure to follow the instructions of your distributor to document why the product is being returned and provide contact details.

If returning to HWM, this can be done by completing the on-line RMA form: https://www.hwmglobal.com/hwm-rma/

If soiled, ensure the unit is cleaned with a mild cleaning solution and soft brush, disinfected, and dried prior to shipment.

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MAN-165-0001-A