AQUAREAD
water monitoring instruments

Instruction Manual

for the

LeveLine®

Range of Level and Baro Probes

and associated

LeveLine® Meter, Utilities & Accessories

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1. Introduction to the LeveLine® Product Range

This manual covers the setup, operation and maintenance of the following equipment and software:

- **LeveLine®** (Level & temperature logger)
- **LeveLine-CTD®** (Level, temperature, conductivity & salinity logger)
- **LeveLine® Baro™** (Barometric pressure logger)
- **LeveLine® Mini™** (SDI-12/Modbus level & temperature transducer)
- **LeveLine® Mini-CTD™** (SDI-12/Modbus Level, temperature, conductivity & salinity transducer)
- **LeveLine® Meter** (Setup / Live data / Data upload accessory)
- **LeveLine® QuickDeploy™ Key** (Deployment accessory)
- **LeveLink™ PC software** (Setup / Calibration / Live data / Data analysis utility)

1.1. What Do They All Do?

1.1.1. LeveLine® Loggers

The Aquaread® LeveLine® range of Level and Baro Logging Probes are self-contained data-logging device that record pressure and temperature continuously during their deployment. They feature highly accurate pressure and temperature sensors, a microprocessor and a large memory, which are powered for up to 10 years by an internal 3.6V lithium battery. The -CTD model also records electrical conductivity.

The LeveLine® Baro version is designed for use above the waterline to record barometric pressure data. This version offers a maximum logging rate of once per minute with a storage capacity of 150,000 records.

The LeveLine® Mini™ Probes do not have any logging ability. These are designed to output live pressure and temperature data to a third party logging device using industry standard interfaces. The -CTD version also outputs live electrical conductivity and salinity data.

The entire LeveLine® range is constructed from ultra-rugged titanium and can be deployed for long periods in hostile environments.

1.1.2. LeveLine® Meter

The LeveLine® Meter is a waterproof (IP67) hand-held device designed to allow full on-site logger setup, data retrieval / storage and live monitoring, which is particularly ideal for pumping operations.

A built-in GPS receiver allows the user to embed GPS coordinates (including altitude) in the Logger's memory as it is deployed so that it appears as part of the dataset upon retrieval.

A built-in barometric air pressure sensor allows live barometric level correction. The meter also has the facility to add a salinity value for live water density compensation.

Data from up to 300 Loggers can be retrieved onto the Meter on site then transferred onto a PC for analysis at a later date.

When connected to a -CTD model Probe, the electrical conductivity sensor can also be easily calibrated.

1.1.3. LeveLine® QuickDeploy™ Key

The QuickDeploy™ Key is a simple plug-in device which allows a pre-programmed logging scheme to be started at the exact instant of deployment. It also embeds a zero depth reference marker in the logged data in order to allow absolute depth measurement from the start and carries out an instant check on the battery and memory levels.

This means loggers can be set up with the desired logging frequencies but no start date & time, then stored on the shelf for any given time period. The user can then take the loggers as required and initiate logging using the QuickDeploy™ Key as they deploy each instrument in the field.

This ensures there is no data lost if the loggers are deployed early and there is no memory and battery wasted if the loggers are deployed late.

1.2. LeveLine® Cabling

A number of cables and adaptors are available to allow for various connection permutations. The following are some of the most popular and useful combinations.

1.2.1. Direct Connection of a LeveLine® Logger to a PC

The LeveLine® PC Kit (Part No. LL-PC-KIT) shown above allows direct connection of a LeveLine® Logger to a PC via a USB port.

The clear USB connector housing contains a red and a green LED. Each time the PC sends data to the LeveLine®, the red LED will flash. Each time the LeveLine® returns data, the green LED will flash.

This is a very useful tool for fault finding. If you experience communications problems, looking at the LEDs will tell you if the problem is with the PC not sending data or the LeveLine® not responding.

If you do not see any flashing LEDs, check the USB Cable drivers are correctly installed. See section 2.4

1.2.2. Connection of a LeveLine® Logger to a PC via an extension cable

This option can be used to setup the Logger, read live data or upload logged data whilst the LeveLine® Logger is installed.

The LeveLine® USB to Extension Adaptor (Part No. LL-USB-EXT-AD) shown above provides an interface between the LL-PC-KIT and any length of LeveLine® extension cable (Part No. EXT-LL-XM).

1.2.3. Connection of a LeveLine® Logger to a LeveLine® Meter

This option can be used to setup the Logger, read live data or upload logged data whilst the LeveLine® Logger is installed. For this, a LeveLine® extension cable (Part No. EXT-LL-XM) is required.

1.2.4. Direct Connection of a LeveLine® Meter to a PC

This option can be used to retrieve data from a LeveLine® Meter, that has been previously uploaded to that Meter from a LeveLine® Logger.

For this, a LeveLine® PC kit is required and a LeveLine® Meter to USB adaptor (Part No. LLM-USB-AD). This adaptor is supplied as standard with the LeveLine® Meter.

1.2.5. Connection of a LeveLine® Logger to a telemetry device

This option can be used to obtain live data from a LeveLine® Logger via a telemetry device.

For this, a LeveLine® extension cable (Part No. EXT-LL-XM) is required along with a LeveLine® Extension to Telemetry Adaptor (Part No. LL-EXT-TEL-AD) as shown above.

For full details of the Telemetry Adaptor wiring and data protocols, refer to section 6

1.3. LeveLine® Battery Life

All LeveLine® Loggers run from a single, dealer replaceable 3.6V Lithium-thionyl Chloride (Li-$SOCL_2$) battery.

The table below shows typical battery life of the standard LeveLine® Loggers at various logging/event checking rates at 25°C. Higher temperatures can increase the rate of self discharge and hence reduce the figures shown.

Logging / Event Checking Interval	Expected Battery Life
0.1 Sec	18 Days
0.5 Sec	23 Days
1.0 Sec	60 Days
15.0 Sec	2.25 Years
1 Min	7.5 Years
> 2 Min	> 10 Years

The table above naturally assumes that the Logger's memory would be cleared down each time it becomes full, otherwise, the Logger would simply stop logging when the memory was full and the battery would then be subject to a quiescent discharge only.

1.3.1. Important Note Regarding Battery Life

If you set a long logging interval but a very short event checking interval, the battery life should be estimated on the event checking interval rate. Even though the logger will not log data every time an event is checked, it will take a reading and hence will use the same amount of battery power as a logged data point. Always choose the longest logging / event checking interval that you can for your application in order to prolong the battery life.

1.4. LeveLine-CTD® Battery Life

All LeveLine-CTD® Loggers run from a single, dealer replaceable 3.6V Lithium-thionyl Chloride (Li-$SOCL_2$) battery.

The table below shows typical battery life of the LeveLine-CTD® Loggers at various logging/event checking rates at 25°C. Higher temperatures can increase the rate of self discharge and hence reduce the figures shown.

Logging / Event Checking Interval	Expected Battery Life
1 Sec	6 Days
15 Sec	90 Days
1 Min	1 Year
5 Min	5 Years
10 Min	10 Years
> 10 Min	> 10 Years

1.4.1. Important Note Regarding Battery Life

If you set a long logging interval but a very short event checking interval, the battery life should be estimated on the **event checking interval rate**. Even though the logger will not log data every time an event is checked, it will take a reading and hence will use the same amount of battery power as a logged data point. Always choose the longest logging / event checking interval that you can for your application in order to prolong the battery life.

1.5. LeveLine® Factory Calibration

All LeveLine® water level Loggers are factory calibrated at five separate pressure points across their pressure range, at two temperatures, 5°C and 25°C. In addition, the -CTD versions are also calibrated at a single electrical conductivity point.

All LeveLine® Baro Loggers are factory calibrated at three separate pressure points across their pressure range, at two temperatures, 5°C and 25°C.

The data produced by this calibration procedure is used to construct a three dimensional calibration curve (surface), which is stored in each Probe's memory and subsequently used to automatically correct temperature and pressure readings prior to output.

The date at which your LeveLine® Logger was last calibrated is shown in the 'LeveLine Status' box on the Setup tab of the LeveLink™ PC software.

1.5.1. Factory Re-calibration of Level and Temperature

The accuracy of LeveLine® Loggers can be adversely affected by physical damage or abuse, improper care and handling, exceeding operating pressure and temperature limits, lightning strikes and similar power surges, as well as normal drift in the device’s electronic components.

Excluding physical damage, the need for factory recalibration is dependent upon the amount of drift you are willing to tolerate.

For optimum performance, factory re-calibration is recommended every 12-18 months.

1.5.2. Re-calibration of the Electrical Conductivity Cell

The electrical conductivity (EC) cell on the -CTD versions can be user calibrated at any time and at any value between 100µS/cm and 99,999µS/cm.

Re-calibration of the EC Cell can be carried out by using either the LeveLink™ PC software (see: Calibrating the Electrical Conductivity Cell on - CTD Probe Models) or the LeveLine® Meter (see: Calibrating the Electrical Conductivity Cell on - CTD Probe Models).

2. LeveLink™ PC Software

LeveLink™ PC software allows full setup and management of the LeveLine® family of Loggers, retrieval, storage, analysis and post correction of logged data from both the Loggers and the LeveLine® Meter, and the generation of spreadsheet, graphic and Google™ Earth files. In addition, LeveLink™ allows calibration of the EC function of the -CTD model Probes.

LeveLink™ is designed to run under Microsoft® Windows® Vista® or later on a stand-alone PC with a minimum screen resolution of 1280 x 960 and an available USB 2.0 socket. Your PC must have Windows® .NET Framework version 4.00 or higher installed. If you are running an earlier version, you will be prompted to download and install a later version of .NET Framework from the Microsoft® website when you first run LeveLink™ setup. Please note, Window® XP® and earlier version are no longer fully supported.

2.1. Cable Requirements

In order to communicate directly with a LeveLine® logger or meter, you will require a LeveLine® PC cable kit. Part number: LL-PC-KIT.

If you wish to connect a PC or Laptop to a LeveLine® logger which is already deployed on an extension cable, you will require an additional USB cable to extension cable adapter. Part number: LL-USB-EX-AD. See section 1.2 for full details of LeveLine® cabling options.

2.2. Downloading LeveLink™ PC Software from the Aquaread® website

The LeveLink™ PC Software is available for download using the following link: http://www.aquaread.com/software-downloads

From the Aquaread® Downloads page, select 'LeveLink-LeveLine Utility'. The software will be downloaded as a .ZIP file.

2.3. Software Installation

Unzip the downloaded .ZIP file into a temporary directory . Browse the temporary directory and click on '**setup.exe**'. You will be given the usual Windows® security warnings. Allow the software to install. Once installed, LeveLink™ will run automatically.

To communicate with the LeveLine® Probe or Meter, two further software 'drivers' need to be installed. These are the '**LeveLine USB Cable**' driver and a '**USB Serial Port**' driver.

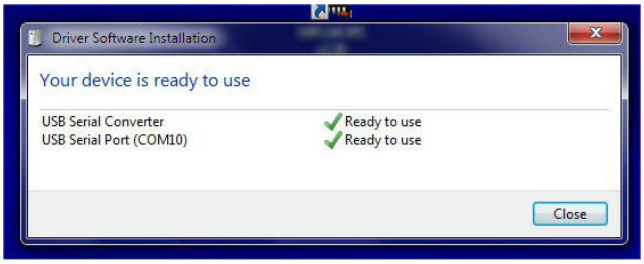
2.4. Driver Installation

Connect the LeveLine® USB interface cable to your PC. You do not need a LeveLine® Logger connected at this point. The 'Found New Hardware' wizard on your PC should activate automatically.

Different versions of Windows® react to plugging USB devices in differently. Earlier versions will give you the option to '**locate and install driver software**'. If this happens, direct Windows® to your temporary directory containing the unzipped download.

If your version of Windows® tries to search the Internet or 'Windows Update' for the drivers, that is OK, but it might take some time. If this occurs, you can stop the search and direct Windows® to your temporary directory.

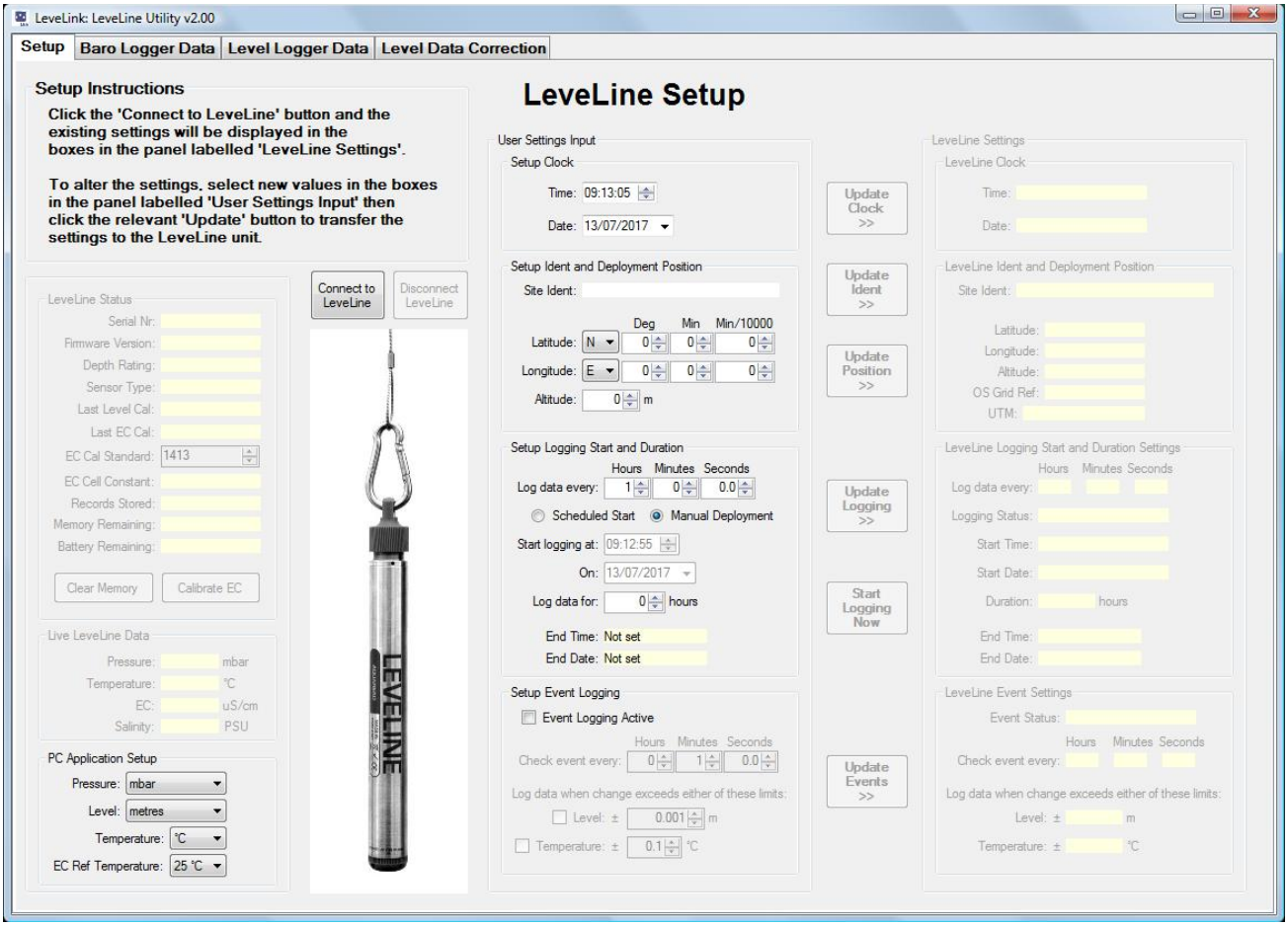
After successful driver installation, the following message should be displayed.



The USB Serial Port number (COM10 in the above example) may be different, but that is fine provided it shows 'Ready to use'. If the drivers do not install properly, refer to the Troubleshooting LeveLink™ section.

2.5. Starting LeveLink™

Select ►Aquaread then ►LeveLink™ from your Programs menu. After an introductory splash-screen has been displayed, the LeveLine® Setup screen will appear:



If you are using a laptop or notebook with a small screen, the window can be resized by dragging the bottom right hand corner.

2.6. LeveLine® Setup Screen Overview

The LeveLine® Setup screen allows you to setup the following parameters:

- The LeveLine® Logger's real time clock
- A unique name (ident) for the LeveLine® Logger

- The LeveLine® Logger's deployment position and altitude
- The LeveLine® Logger's logging start date and duration
- The LeveLine® Logger's logging rate
- The LeveLine® Logger's event logging criteria
- The LeveLink™ PC application's preferences

In addition, this screen allows you to view live data from a connected LeveLine® Logger or LeveLine® Mini and to clear the Logger's memory. When used with a -CTD type LeveLine®, the electrical conductivity cell (EC) can be calibrated.

Before attempting to adjust any of the parameters on the screen, connect a LeveLine® Logger.

2.6.1. On Screen Help

Help has been provided in this software in the form of 'Tool Tips'. If you want to know what a control button does or what a data box displays, simply move your mouse pointer over the item in question. A Tool Tip will appear after a few seconds to give you more information.

2.6.2. Connecting a LeveLine® Probe to your PC

To connect a LeveLine® Probe directly to your PC, the LeveLine® PC Kit (Part No. LL-PC-KIT) described in section 1.2 should be used. Connect one end of the cable to the LeveLine® Probe, aligning it as shown below, and the other end to a spare USB port on your PC.

If you wish to setup or retrieve data from a LeveLine® Logger whilst it is in-service, in a bore hole for instance, an extension lead and USB adapter will be required. See section 1.2.2 for further details.

Once Windows® has recognised the device, click on the 'Connect to LeveLine®' button located just below the Setup Instructions. The PC will communicate with the LeveLine® Probe and begin to display live data in the LeveLine® Data window.

In addition, the LeveLine® Status window will be populated with the following data uploaded from the Logger:

- Serial number
- Firmware revision
- Depth rating
- Sensor type
- Last calibration date
- Last EC (conductivity) calibration date (-CTD Version only)
- The EC calibration standard last used (-CTD Version only)
- The EC cell constant (-CTD Version only)
- Number of records stored
- Memory capacity remaining

- Battery capacity in % remaining

On the right hand side of the screen, the settings currently held in the LeveLine® Logger will be displayed. Please note, when connected to a LeveLine® Mini, these settings are irrelevant because the Mini Probes do not have any logging facility or a real-time clock.

2.6.3. Changing and Updating the LeveLine® Logger's Settings

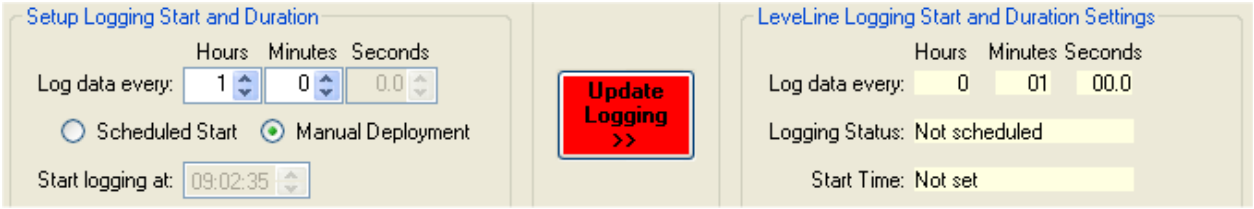
The window located on the right hand side of the screen labelled 'LeveLine Settings' will automatically be populated with data from the attached Logger.

The window located down the centre of the PC screen labelled 'User Settings Input' allows you to alter any of the individual settings. For example, to alter the Logger's ident, input the revised details in the 'Site Ident' box (which is within the 'Setup Ident and Deployment Position' window) then click on the 'Update Ident' button. This will transfer the revised ident to the Logger and the 'Site Ident' box in the 'LeveLine Settings' window will be updated.

2.6.4. Update Buttons

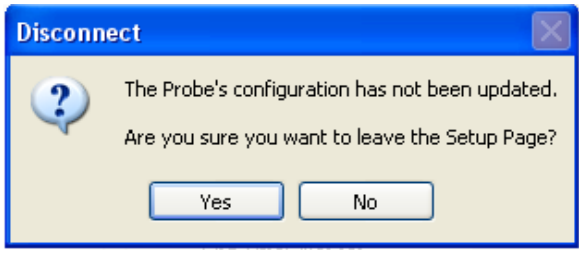
You will notice that adjacent to each block of settings, there is a corresponding 'Update' button. If the data stored in the Logger is the same as the data displayed within the 'User Settings Input' boxes, the associated update button will be grey.

If the data stored in the Logger differs from the data displayed within the 'User Settings Input' boxes, the associated update button will be red as shown below.



This is to remind you to transfer settings that have been changed.

If any of the Update buttons are red, the PC software will prompt you to update the settings in the Logger if you try to disconnect the Logger, leave the current screen or close the program.

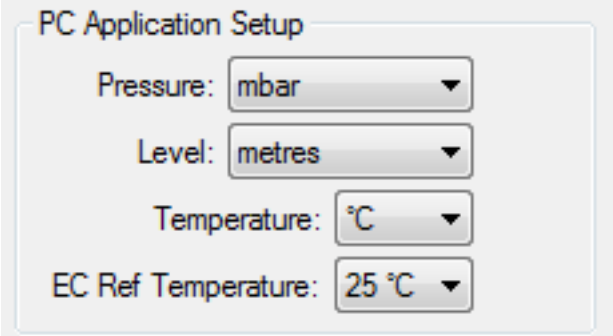


2.6.5. PC Application Setup

The first thing to do when using LeveLink™ is to setup your personal preferences. These are selectable in the PC Application Setup window.

The selections made here will be used throughout the PC application for all data display

and file outputs.



You may choose to display Pressure in any one of the following units:

- mbar (millibar)
- bar
- mmHg (millimetres of mercury)
- inHg (inches of mercury)
- cm water
- inches water
- kPa
- psi

You may choose to display Level in any one of the following units:

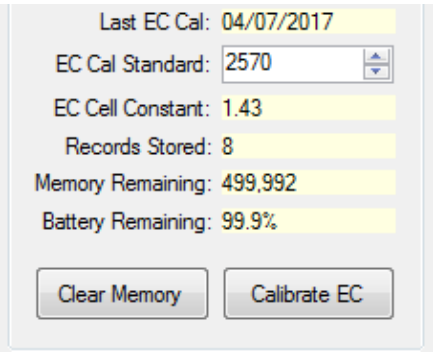
- meters
- centimetres
- millimetres
- feet
- inches

You may choose to display Temperature in either centigrade or Fahrenheit.

When using a -CTD version, you may choose to display electrical conductivity (EC) referenced (corrected) to 25°C, 20°C or absolute (ABS). Absolute EC does not have any temperature correction applied.

2.7. Calibrating the Electrical Conductivity Cell on - CTD Probe Models

When connected to a – CTD Probe, the dedicated EC calibration boxes will be populated and the Calibrate EC button will be enabled.



In the example above, it can be seen that the EC cell was last calibrated on 04/07/17 using a calibration standard of 2570µS/cm, and the resultant cell constant was 1.43.

2.7.1. EC Calibration Standards

EC calibration is always carried out at a single point. There is a choice of two Aquaread® calibration standards, or you can use any third party calibration standard value between 100µS/cm and 99,999µS/cm.

The Aquaread® standards are: Aquaread® RapidCal™ (EC value 2570µS/cm at 25°C) for general use, and Aquaread® SC-35 (EC value 53,065µS/cm at 25°C), which is specifically for use when measuring EC and salinity in sea water.

The calibration solution value you use to calibrate EC should always be chosen to be as near to the readings you expect to see in the field as possible. If you are not sure what values to expect, RapidCal™ is a good choice as this will give reasonably accurate readings across a wide range of EC values.

For best results, calibrate as close to 25ºC as possible. The probe will compensate for temperature variation in the Calibration Standard during calibration.

2.7.2. Recognising the EC Cell

The -CTD Probes all have an elongated nose sleeve covering the EC cell contacts.

The black plastic nose sleeve (shown removed on the right of the photo) forms an integral, working part of the Probe's EC measurement system, and MUST be fitted during calibration and measurement for correct operation.

2.7.3. EC Calibration Technique

1. Remove the nose sleeve from the Probe, wash the EC cell and the sleeve in clean water, dry thoroughly, then replace the nose sleeve.
2. Drop the Probe into a calibration bottle filled with EC Calibration Standard and agitate to remove any air bubbles from inside the sleeve.
3. **Ensure the liquid level is above the top row of holes in the nose sleeve. Low liquid level will result in erroneous EC calibration.**
4. Connect the Probe to a PC running LeveLink™ and wait until the temperature and EC measurements are completely stable.
5. Ensure the temperature of the solution is between 5ºC and 40ºC (41ºF -104ºF).
6. Enter the EC value of your calibration solution at 25ºC into the EC Cal Standard box. If using Aquaread® RapidCal™, this value would be 2570.
7. Click the 'Calibrate EC' button.

You will be prompted to confirm that you want to calibrate EC and to confirm that the correct calibration standard has been entered.

If the software detects a problem, an error message will be displayed. Possible errors are:

- Temperature out of range. Must be between 5ºC and 40ºC (41ºF -104ºF).
- EC Calibration value out of range. Must be between 100µS/cm and 99,999µS/cm.
- Large differential between the selected calibration value and the actual EC reading, which could indicate an incorrect calibration solution value
- Readings are unstable.

If any of these errors are displayed, take remedial action and try again.

If calibration is successful, a 'Calibration Complete' message will be displayed and the dedicated EC calibration boxes will be refreshed with new values.

After calibration, rinse the Probe in fresh water.

2.7.4. EC Cell Constant

The EC cell constant is an indication of the health of the EC cell. Nominally, the EC cell constant should be around 1.25. This can vary with different calibration standard values and calibration temperatures.

If the EC cell constant is reported above 2.00 or below 0.5, carefully clean the EC cell contacts and the inside of the nose sleeve. Also check your calibration solution is fresh and that you have input the quoted value (at 25ºC) during calibration.

2.7.5. Frequency of EC Calibration

Ideally, EC calibration should be carried out regularly based upon the levels of soiling the Probe experiences.

On a regular basis, thoroughly clean the inside of the nose sleeve and the four metal EC contacts situated in the EC cell with a soft cloth or toothbrush and non-abrasive detergent. **Never use solvent or alcohol based products to clean the EC cell**. After cleaning, replace the nose sleeve and re-calibrate.

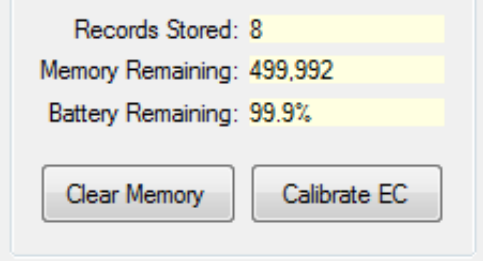
2.8. LeveLine® Setup In Detail

The following sections provide detailed guidance for setting up a LeveLine® Logger and assumes you have connected a LeveLine® Logger to your PC and connected to it by clicking the 'Connect to LeveLine' button.

Once a LeveLine® is connected, the 'Disconnect LeveLine' button will become live and should be used prior to disconnecting the LeveLine® unit.

2.8.1. Checking Memory and Battery Status (logging versions only)

This first thing to do prior to any setup is to check the LeveLine's memory and battery status. This information is displayed in the 'LeveLine Status' window.



If you are planning a new deployment, ensure there is sufficient memory remaining for the planned deployment duration at the planned logging rate. If the Logger runs out of memory, it will stop logging. Also ensure the battery is in good condition.

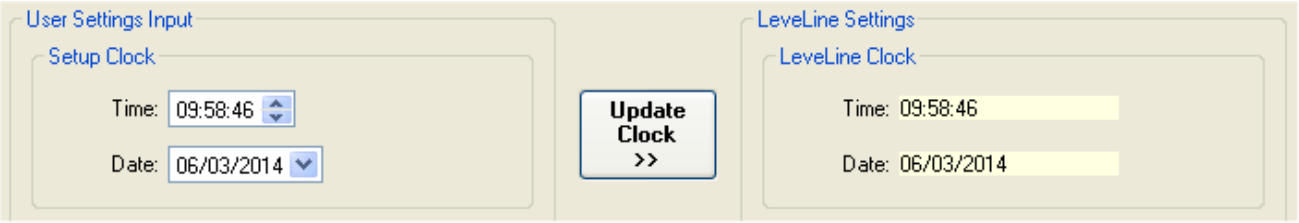
If your battery is showing below 10% capacity, it is strongly recommended that you have it replaced by your dealer prior to any further deployment. See section 1.3 for further details concerning battery life.

2.8.2. Clearing the LeveLine's Memory (logging versions only)

At the bottom of the LeveLine® Status window there is a 'Clear Memory' button. If you want to clear the Logger's memory, click this button. **Please use this feature with care. Once the Logger's memory has been cleared, all level data stored in the Logger will be permanently lost.** The 'Clear Memory' button does not clear any of the user settings.

2.8.3. LeveLine® Clock Setup (logging versions only)

The clock setup windows are shown below.



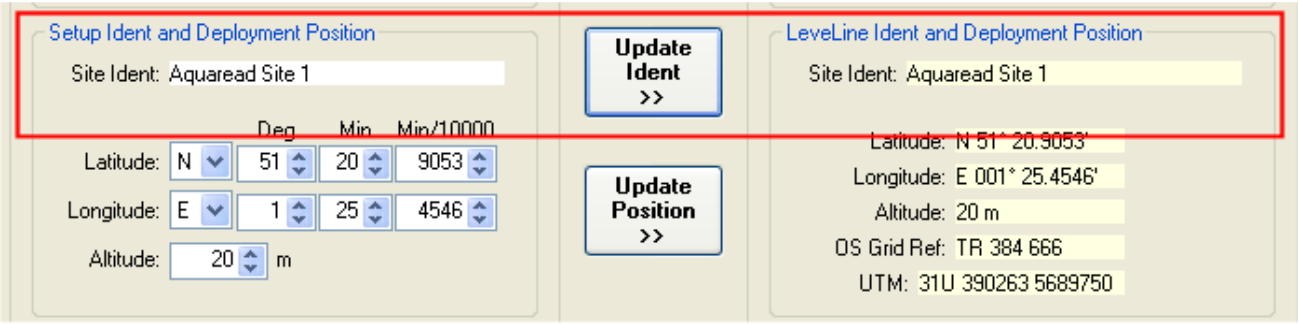
The boxes within the window to the left labelled 'Setup Clock' show the current time and date from your PC. You can override/change this time and date if you want to by directly altering the values within the boxes.

The boxes within the window to the right labelled 'LeveLine Clock' shows the time and date of the connected LeveLine® Logger.

If the two clocks disagree by more than a few minutes, the 'Update Clock' button will be coloured red. To synchronise the clock in the LeveLine® Logger to the time shown in the 'Setup Clock' window, click the 'Update Clock' button.

2.8.4. LeveLine® Site Ident Setup (logging versions only)

The Site Ident windows are shown below bordered in red.



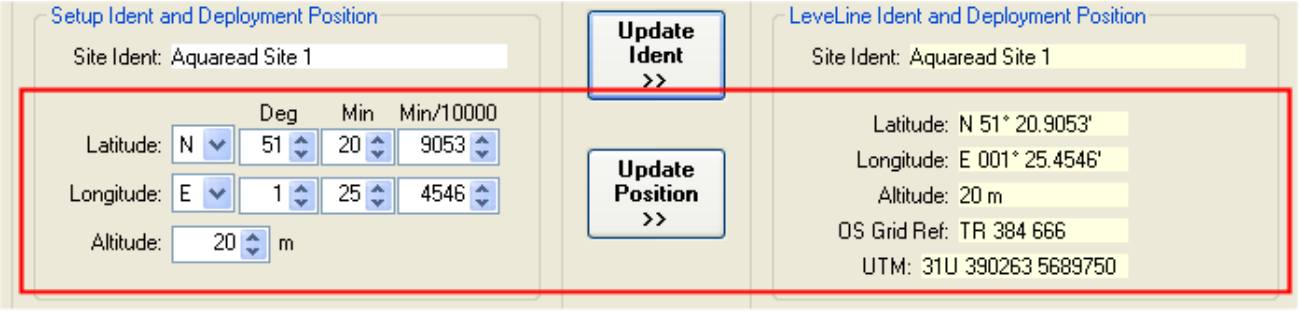
The boxes within the 'LeveLine Ident and Deployment Position' window to the right show the current data programmed into the connected LeveLine® Logger.

To alter the Site Ident, input the new site name (up to sixteen characters) into the Site Ident box on the left and click the 'Update Ident' button to transfer the new Ident to the connected LeveLine® Logger. Please note, some special characters available on your PC keyboard are not permitted and will not be displayed.

If the Ident stored in the Logger differs from the Ident displayed within the 'Site Ident' input box, the 'Update Ident' button will be red. This is to remind you to transfer settings that have been altered. When the PC and Logger agree, the button will turn grey.

2.8.5. LeveLine® Deployment Position Setup (logging versions only)

The Deployment Position windows are shown below bordered in red.



The boxes within the 'LeveLine Ident and Deployment Position' window to the right show the current data programmed into the connected LeveLine® Logger.

From new, the LeveLine® Logger will not have a deployment position programmed and the position boxes will be filled with dashes (----------).

To alter the Deployment Position, input the new deployment position Latitude, Longitude and Altitude into the relevant boxes on the left and click the 'Update Position' button to transfer the new Ident to the connected LeveLine® Logger.

Latitude must be entered as hemisphere (N/S), degrees of latitude (0-90), minutes of latitude (0-59) and fractions (1/1000ths) of minutes of latitude.

Longitude must be entered as hemisphere (E/W), degrees of longitude (0-180), minutes of longitude (0-59) and fractions (1/1000ths) of minutes of longitude.

Altitude (above mean sea level) must be entered in metres. **Inputting an accurate altitude is important as this is one of the parameters used to calculate level from raw pressure.**

This information is most easily obtained from a GPS. If you are using the LeveLine® Logger in association with an Aquaread® LeveLine® GPS Meter, the deployment position and altitude can be uploaded to the Logger from the Meter on site at the touch of a button.

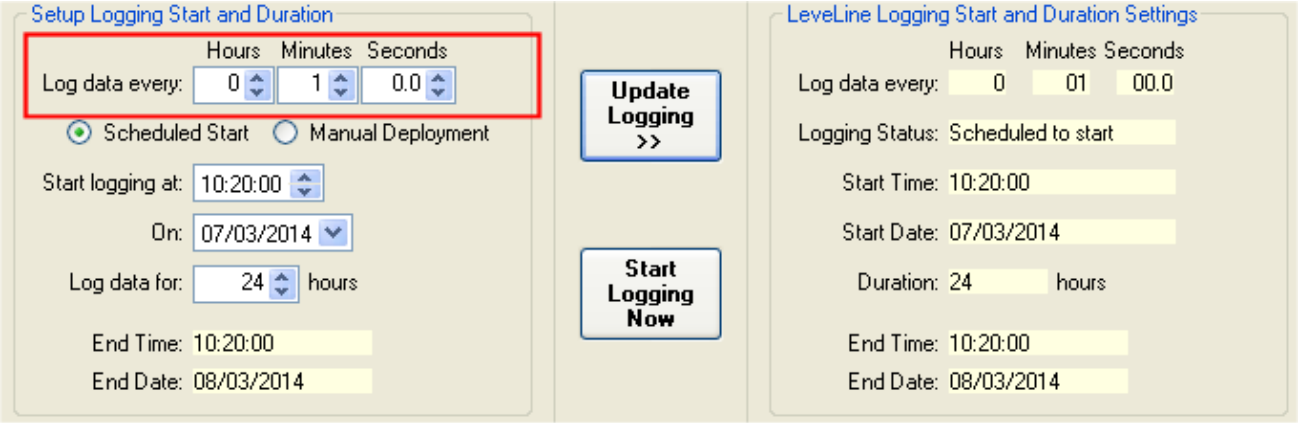
When a deployment position has been transferred, the Logger will output the position in two additional formats, which are for information only. The first additional position format is Ordnance Survey (OS) Grid Reference. This grid reference system is only valid within the United Kingdom. The second additional position format is Universal Transverse Mercator (UTM) Grid Reference. This grid reference system is valid worldwide.

If the deployment position stored in the Logger differs from the position displayed within the setup input boxes, the 'Update Position' button will be red. This is to remind you to transfer settings that have been altered. When the PC and Logger agree, the button will turn grey.

To reset the deployment position in the Logger to all dashes, set all the numbers in the Latitude and Longitude boxes on the left to zeros and transfer to the Logger.

2.8.6. LeveLine® Scheduled Logging Start, Logging Interval and Duration Setup

This is the most important part of the LeveLine® setup. The logging interval (time between logged data points) must always be set up.
The LeveLine® Logger can then be set up to start logging data automatically at a pre-determined time for a set duration, or it can be set up for manual deployment. This section covers logging interval, scheduled logging start and logging duration.



To set up the logging interval, adjust the boxes beside the 'Log data every:' label shown above bordered in red. Different models of LeveLine® Loggers have different permissible logging rates.

- Standard LeveLine® Loggers can be set up to log data as fast as ten times per second (log data every 0.1 second) and as slow as once every five days (120 hours).

- LeveLine - CTD® Loggers can be set up to log data as fast as once per second and as slow as once every five days (120 hours).

- LeveLine® BARO Loggers can be set up to log data as fast as once per minute and as slow as once every five days (120 hours).

It is advisable to choose the slowest logging rate that your application can comfortably support. This is for two reasons: battery life and memory capacity. If you choose an extremely fast logging rate, the Logger's memory will fill up very quickly and you will have massive files to handle when you come to download and analyse your data.

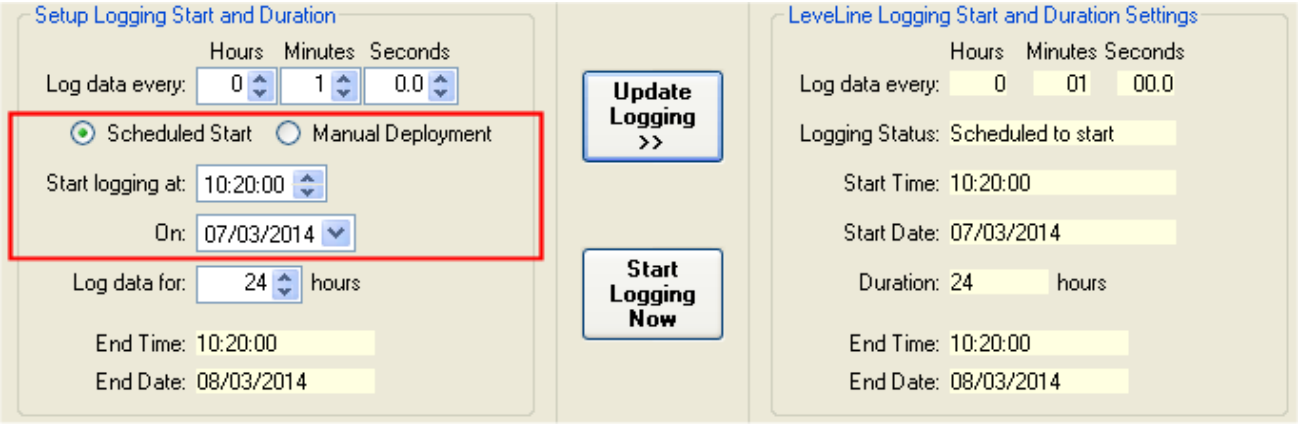
Also, your battery will be depleted quickly. For example, at a logging rate of 0.2 seconds, the LeveLine® will be logging 18,000 points per hour. This will obviously deplete the available memory extremely quickly.

If you set a long logging interval but a very short event checking interval, the battery life should be estimated on the event checking interval rate. Even though the logger will not log data every time an event is checked, it will take a reading and hence will use the same amount of battery power as a logged data point.

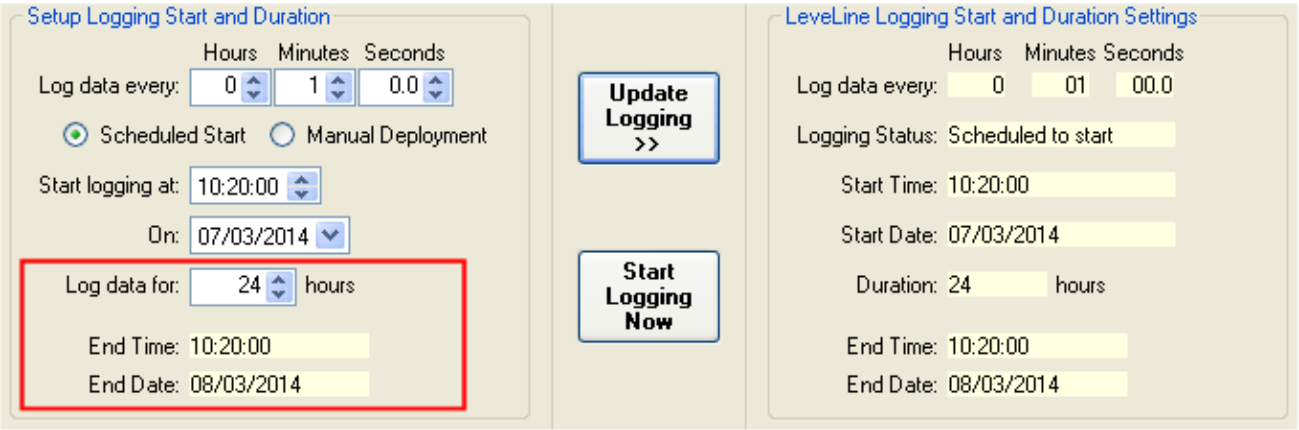
Unless you are monitoring live pumping operations or similar dynamic events, water levels, EC and barometric pressures tend to alter reasonably slowly. For this reason, logging rates between 1 and 15 minutes, and barometric pressure logging rates between 15 minutes and 1 hour are normally recommended.

Using these rates will result in reasonably sized data files and many years battery life. For further details concerning battery life, see section 1.3

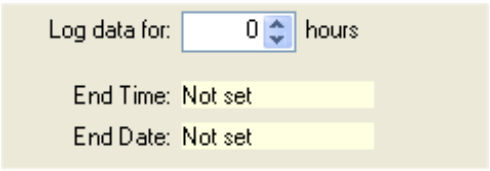
Next, click the 'Scheduled Start' option and enter the time date you want to start logging data. The controls for this are shown below bordered in red.



Finally, select the number of hours you want to log data for. As you adjust the 'Log data for:' values, the End Time and End Date boxes will automatically update. See below bordered in red.



If you want to log data indefinitely, set the value in the 'Log data for:' to zero.



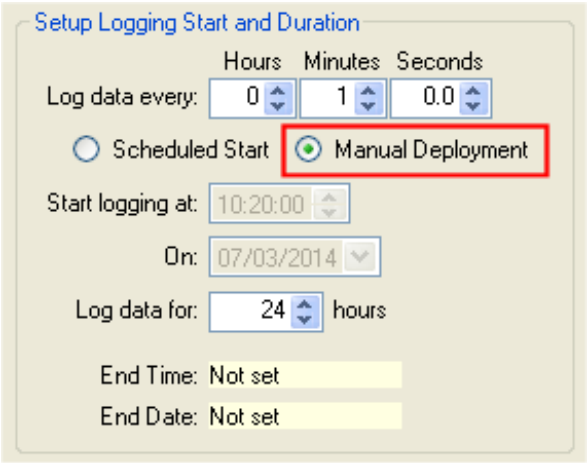
If you do this, the End Time and End Date boxes will show 'Not set' as shown above, and the Logger will continue to log data until you choose to stop logging manually or the Logger runs out of memory or battery capacity.

Finally, once the scheduled logging start, logging interval and duration (if required) have been set up, transfer the settings to the Logger by clicking the 'Update Logging' button.

2.8.7. LeveLine® Manual Logging Start, Logging Interval and Duration Setup

The LeveLine® Logger can be set up to start logging data automatically at a pre-determined time for a set duration. This has been fully covered in the previous section.

If, on the other hand, you are not certain of the exact time and date you want to start logging, the Logger can be set up for manual deployment. This involves setting up the logging interval and optional logging duration, then forcing the logger to start logging at the exact time of deployment using a PC running LeveLink™ software, a LeveLine® Meter or a QuickDeploy™ Key.



First, set the logging interval as described in the previous section.
Next, select Manual Deployment as shown above. Finally, select the number of hours you want to log data for.

Since, in this case, you are not specifying a time and date for logging to start, the End Time and End Date boxes will remain at 'Not Set'. The actual time and date the logged data will end will be the chosen number of hours after you manually deploy the Logger.

If you want to log data indefinitely after the manual deployment, set the value in the 'Log data for:' to zero.

Finally, once the logging interval and duration (if required) have been set up, transfer the settings to the Logger by clicking the 'Update Logging' button. You will notice that the 'Logging Status' will now show 'Not Scheduled' See illustration below.

Remember to subsequently start the LeveLine® logging when you deploy it! See section 3.4 for further details of on-site deployment.

2.8.8. Manual Logging Start using LeveLink™

If, having set up the logging interval and duration (if required) as detailed in the previous section, you subsequently want to start the LeveLine® logging, click the 'Start Logging Now' button.

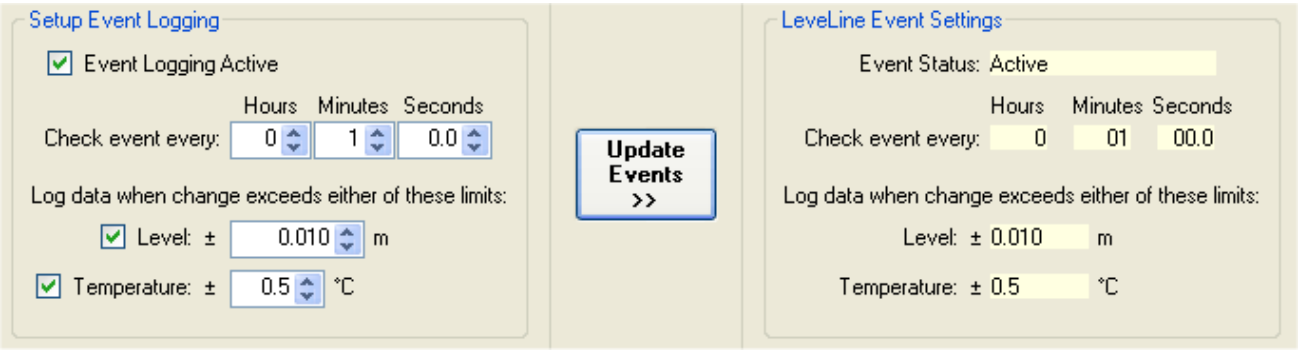
After a few seconds the 'Logging Status' will change to 'Logging', the End Time and Date will be populated (if you have set a logging duration) and the 'Start Logging Now' button will change to 'Stop Logging Now'. To stop logging manually, click this button.

2.8.9. Overriding a Scheduled Logging Start

If you have set up a scheduled logging start time and date but subsequently want to start logging earlier, the scheduled start can be overridden at any time by performing a manual start using a PC running LeveLink™, a LeveLine® Meter or a QuickDeploy™ Key.

2.8.10. LeveLine® Event Logging Setup

A useful feature of the LeveLine® Loggers is the ability to automatically increase the logging rate if rapid changes in either level or temperature/salinity are detected. Using this feature, memory can be saved by using a long logging interval (say several hours or more), but any rapid changes will be logged in full detail.



To activate event logging, first tick the 'Event Logging Active' tick box. Next select the parameter that you want to use for event logging. In the example above, both level and temperature have been selected. You can choose either or both.

When using a -CTD version, the Temperature event is replaced by a Salinity event. This is extremely useful when conducting salt water intrusion studies in coastal regions.

Next, select the time interval at which the event should be monitored. This value must be more regular than the normal logging rate. In the example above, the level and temperature will be monitored every minute.

Finally, set the trigger point for the event logging, in other words, the amount each value must change from the previously logged value in order to be logged.

So, in the example above, the level and temperature will be monitored every minute, but will only be logged if the level varies by more than 10cm from the previous logged value or the temperature varies by more than 0.5°C from the previously logged value.

Finally, as with all settings, once the event logging criteria have been set up, transfer the settings to the Logger by clicking the 'Update Events' button.

2.9. Preparing to Upload Logged Data From a LeveLine® Logger or LeveLine® Meter

This section deals with retrieving logged data either directly from a LeveLine® Logger, or from a LeveLine® Meter that has previously been used to retrieve data from a Logger in the field.

As far as the LeveLink™ software is concerned, the technique is identical. That is to say, when a LeveLine® Meter containing logged data is connected to the PC, the Meter is completely transparent. The only thing the LeveLink™ software sees is the Status, ID and logged data uploaded from original Logger.
The LeveLine® Meter can hold data sets from up to 300 separate LeveLine® Loggers. In order to upload the desired data set from the Meter, that data set must first be selected on the Meter. See the following sections for further details concerning preparing the LeveLine® Meter for PC uploads.

2.9.1. Connecting a LeveLine® Logger to your PC

To connect a LeveLine® Logger directly to your PC, the LeveLine® PC Kit (Part No. LL-PC-KIT) described in section 1.2 should be used. Connect one end of the cable to the LeveLine® Logger, aligning it as shown below, and the other end to a spare USB port on your PC.

If you wish to retrieve data from a LeveLine® Logger whilst it is in-service, in bore hole for instance, an extension lead and USB adapter will be required. See section 1.2.2 for further details.

2.9.2. Connecting a LeveLine® Meter to your PC

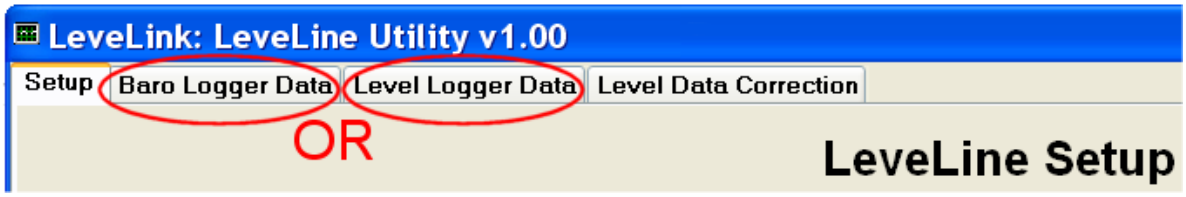
To connect a LeveLine® Meter to you PC, the same PC kit detailed above should be used in conjunction with a LeveLine® Meter to USB adaptor (Part No. LLM-USB-AD) shown below.

Ensure the LeveLine® Meter has batteries installed but is switched off. Connect the LeveLine® Meter to USB adaptor to the Meter as shown above, then connect to your PC using the LeveLine® PC Kit. Switch the Meter on.

Get the Meter ready for data transfer by pressing the MR (Memory Recall) key then selecting the desired data set using the up/down arrow keys. Once the title of the desired data set is displayed on the Meter's screen, you are ready to proceed.

2.10. Uploading Logged Data from a LeveLine® Logger or LeveLine® Meter

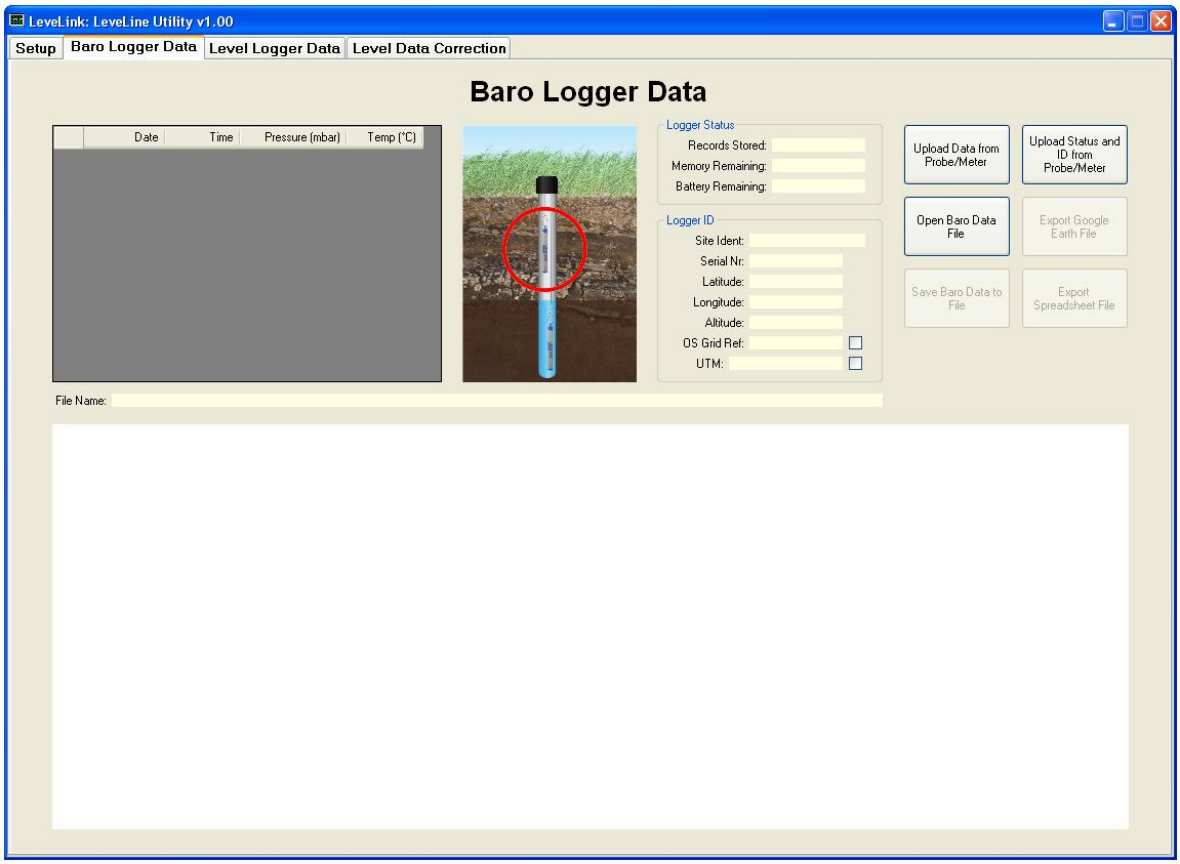
From here on, whether connected to a Logger or Meter, the technique for uploading data is identical. First identify the Logger type and choose the corresponding upload tab.



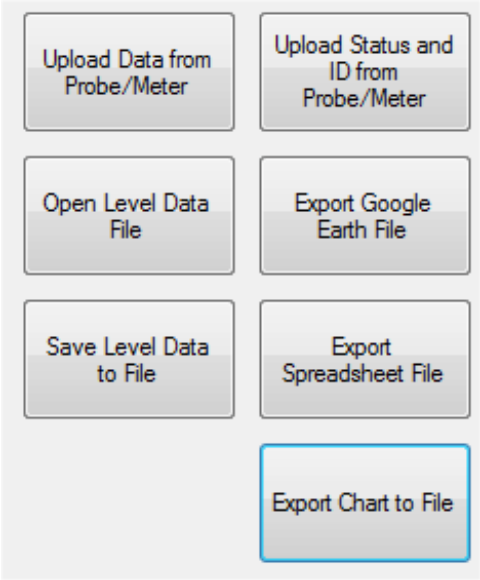
If your data was air pressure data logged with a Baro Logger, click on the 'Baro Logger Data' tab. If your data was water level data logged with a Level Logger, click on the 'Level Logger Data' tab.

The following example shows Baro Logger Data, but the technique is identical for both Logger types.

After clicking one of the Data tabs, the following screen will be displayed.



This data upload screen has seven control buttons on the right hand side.



Initially, just three of the buttons will be active. These are:

- Upload Data from Probe/Meter
- Upload Status and ID from Probe/Meter
- Open Baro/Level Data File

The 'Upload Data from Probe/Meter' button will initiate communications with the connected Probe or Meter, then automatically upload the probe's Status, ID and all logged data.
During data upload, a progress bar is displayed along with an 'Abort' button. If you click on the Abort button before the upload is complete, the data uploaded so far will be displayed but the transfer will halt.

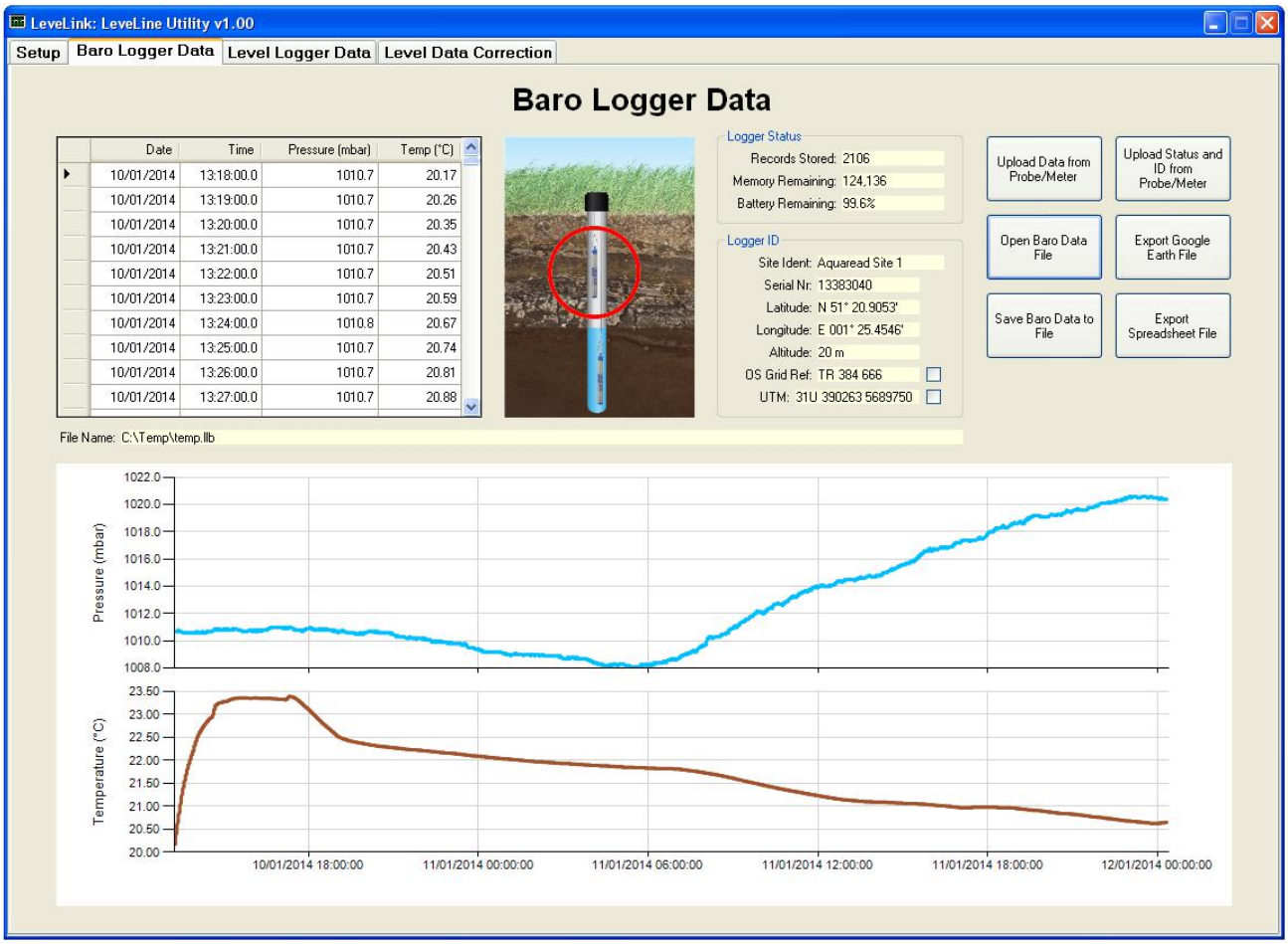
The 'Upload Status and ID from Probe/Meter' button will initiate communications with the connected Probe or Meter, then upload the probe's Status and ID only.

The 'Open Baro Data File' button will allow you to open a previously saved logged data file.

If, when you click on one of the Upload buttons, you have chosen the wrong upload tab, e.g. you are attempting to upload Level Logger data using the Baro Logger Data tab, a warning dialogue will be displayed.

If this occurs, switch to the correct tab and try again.

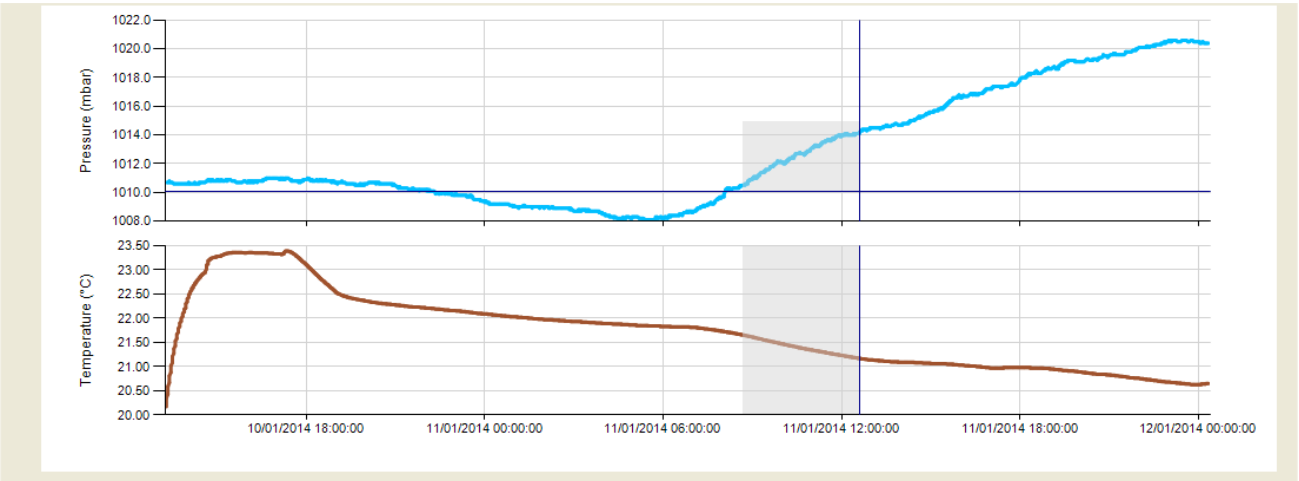
2.10.1. Viewing Logged Data



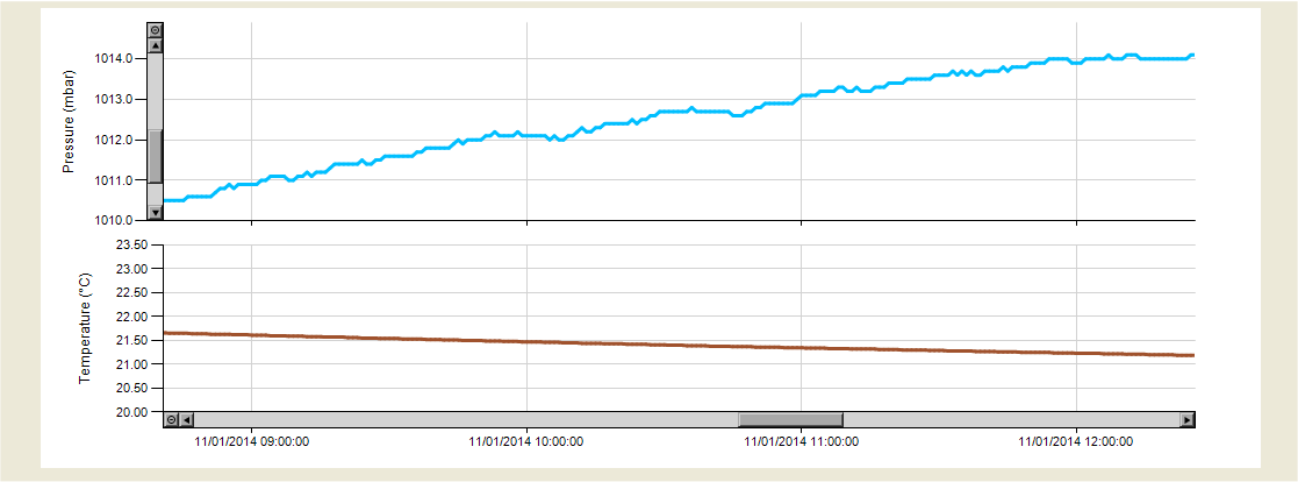
After upload, the data is displayed in both tabulated and graphical formats. The Logger's Status and ID boxes will also be populated. If the data you have uploaded has come from a Logger via a Meter, the values in these boxes will represent the status of the original Logger. If you are using a -CTD Probe, a third chart will appear below the temperature chart displaying the EC data. Use the scroll bar to view this chart.

2.10.2. Zooming In and Out

In order to examine a section of the graphical data in closer detail, it is possible to zoom-in on any section of the chart. To zoom-in, simply use your mouse pointer and mouse left button to draw a grey box around the section of data you are interested in as shown below. You can draw the box on either the pressure or temperature charts.



As soon as you release the mouse button, both charts will re-draw displaying just the selected portion as shown below.



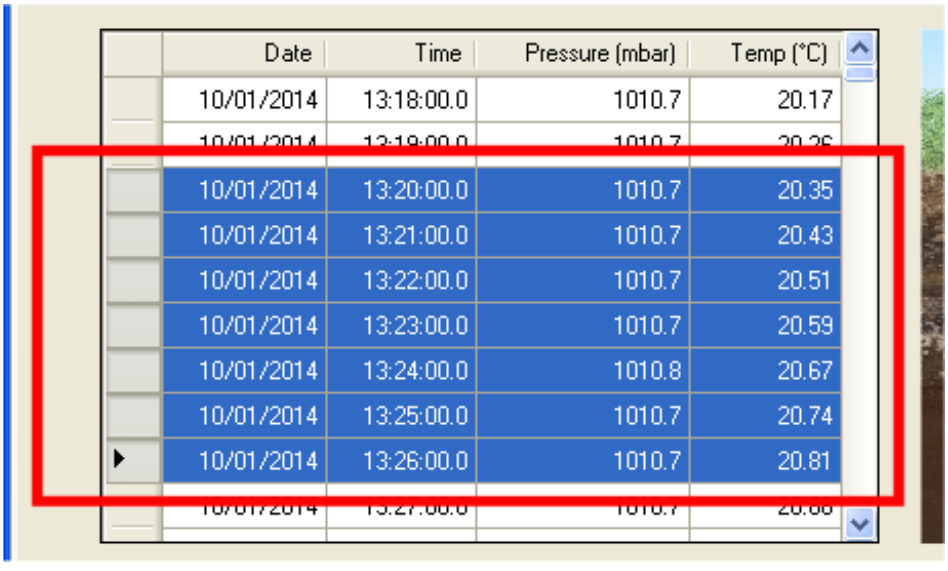
To move around the charts, use the horizontal and/or vertical scroll bars. To zoom back out on either axis, click the round control at the end of the relevant scroll bar. To export the charts to a graphics file, click the 'Export Chart to File' button.

2.10.3. Saving Logged Data

There are two options available for saving logged data. You can either save the entire set of logged data, or you can select sections from the tabulated data to save.

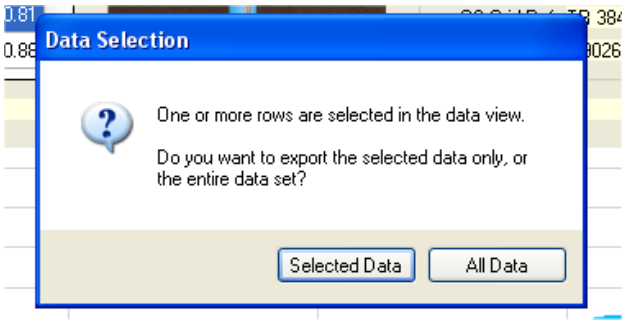
To save the entire data set, click on the 'Save Baro (Level) Data to File' button. You will be asked for a file name, (which will default to the site ident or probe's serial number) then the file will be saved with either a .llb (LeveLine® Baro) extension or a .llw (LeveLine® Water) extension depending upon which tab you are saving data from.

To save just a portion of the data set, use your mouse in conjunction with your shift and/or Ctrl keys (in normal Windows fashion) to highlight the desired records in the table as shown below, then click on the 'Save Baro (Level) Data to File' button. The highlighted section can be any number of records and need not be contiguous.



Date	Time	Pressure (mbar)	Temp (°C)
10/01/2014	13:18:00.0	1010.7	20.17
10/01/2014	13:20:00.0	1010.7	20.35
10/01/2014	13:21:00.0	1010.7	20.43
10/01/2014	13:22:00.0	1010.7	20.51
10/01/2014	13:23:00.0	1010.7	20.59
10/01/2014	13:24:00.0	1010.8	20.67
10/01/2014	13:25:00.0	1010.7	20.74
10/01/2014	13:26:00.0	1010.7	20.81

When you click on the 'Save Baro (Level) Data to File' button, you will be asked to confirm if you want to save the entire data set or just the selected section.



Choose 'Selected Data' to export (save) just the highlighted data.

2.10.4. Retrieving Logged Data Files

Once data has been saved by LeveLine® with either a .llb (LeveLine® Baro) extension or a .llw (LeveLine® Water) extension, the data can be easily retrieved at any time in the future using the 'Open Baro (Level) Data File' button.

2.10.5. Exporting Logged Data to a Spreadsheet

Data is exported from LeveLink™ for use in spreadsheets in a tab delimited format. This data format can be easily imported into all common spreadsheet applications.

As with 'Saving Logged Data' explained above, you can either export the entire set of logged data, or you can select sections from the tabulated data to export. If you want to include the OSGB or UTM position grid references with your data, tick the appropriate check-box. When you have made your selection, click the 'Export Spreadsheet File'.

2.10.6. Exporting Logged Data to Google™ Earth Files

Google™ Earth files are exported in Google's proprietary Keyhole Markup Language with a .kml extension, and can be directly imported into either Google™ Maps or Google™ Earth, where a data summary is overlaid on maps or satellite images respectively.

Please note: only data associated with a valid GPS position can be exported as Google™ Earth files.

To export a Google™ Earth file, select the desired data then click on the 'Export Google Earth File' button. You will be asked to specify a file name, which will default to the site ident or probe's serial number. A .kml extension will automatically be added.

When exporting data for display in Google™ Earth, LeveLink™ does not export every single data point. The software picks the key data points and outputs a summary including calculated averages and ranges. See the example on the next page for further details.

2.10.7. Viewing Files in Google™ Earth

To view your files in Google™ Earth, you will need to log on to the Google™ website and install the Google™ Earth application on your computer. This is free of charge at present.

Once you have downloaded Google™ Earth and have it running, follow these steps:

1. Click on '**File**'.
2. Select '**Open**' from the list.

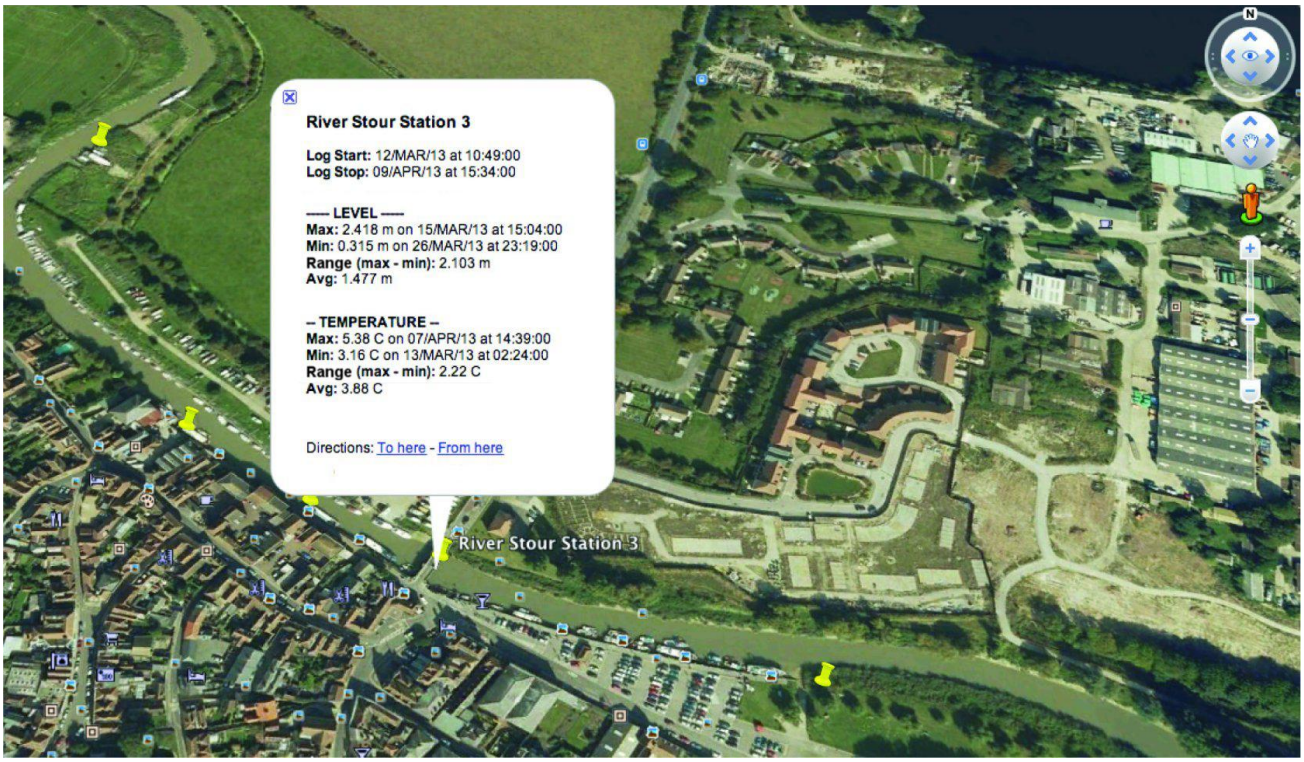
3. Browse for the file you exported from LeveLink™, and select it.

You will now be able to view your data overlaid on Google™ Earth Satellite images. Each data point is represented by a yellow pushpin, and all the data points are listed in a column on the left of the screen. To view the data associated with each pin, either click on the pin or click on the data point in the list.

Please note: Although you have downloaded the Google™ Earth application and are running it from your PC, you still need to be connected to the Internet in order for the application to access satellite images.

A typical Google™ Earth image follows.

2.10.7.1. Typical Google™ Earth Image



The summary associated with your data point includes the following:

- Logging start and stop times
- Minimum and maximum pressure/level recorded
- Change in pressure/level (range)
- Average pressure/level
- Minimum and maximum temperature recorded
- Change in temperature (range)
- Average temperature

Please note: If you highlighted portions of your data in the data table, only the highlighted data will be used when building the Google™ Earth summary.

If you did not highlight any data in the data table, the entire data file will be used to build the data summary.

2.11. Level Data Correction

The LeveLine® Loggers simply log temperature and air/water pressure. In order to translate these values into actual water levels, the data must be merged and corrected. This is taken care of under the 'Level Data Correction' tab.

If you have logged water pressure data using an ABS (absolute) type Level Logger, it is normal practice (though not essential) to have logged this data concurrently with local air pressure using a BARO (barometric pressure) type logger.

If you have logged water pressure data using a GAUGE (vented) type Level Logger, separate barometric pressure data is not required for level correction.

2.11.1. Loading Logged Data

Prior to any data correction, the data for correction must be loaded into LeveLink™ as described in section 2.10

Data can be loaded either directly from a LeveLine® Logger, or from a LeveLine® Meter that has previously been used to retrieve data from a Logger in the field.

Alternatively, data that has been previously retrieved and saved to your PC can be re-opened as described in section 2.10.4

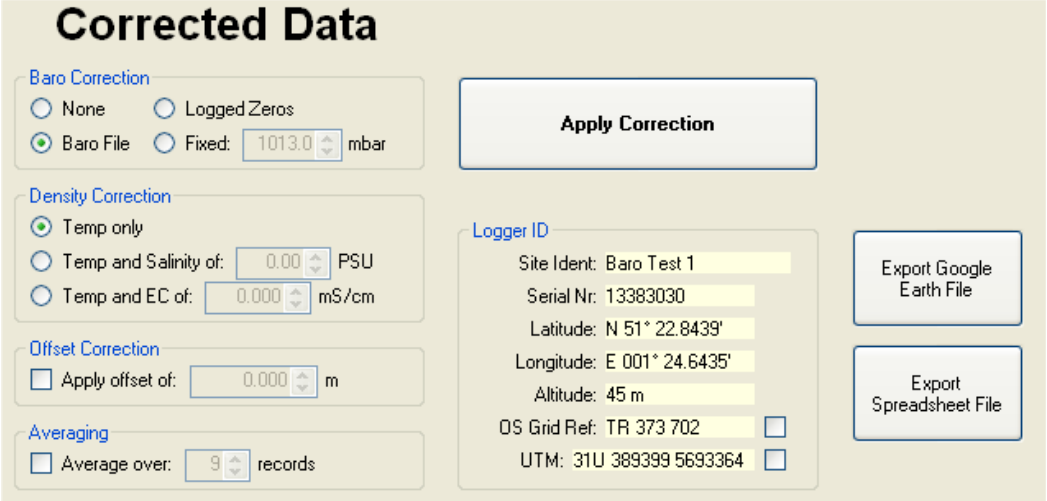
If you plan to correct water pressure data logged using an ABS (absolute) type Level Logger, you should load your water pressure data into LeveLink™ under the Level Logger Data tab. You should then load your associated air pressure data (if available) into LeveLink™ under the Baro Logger Data tab.

If you plan to correct water pressure data logged using a GAUGE (vented) type Level Logger, you should load your water pressure data into LeveLink™ under the Level Logger Data tab. No associated barometric pressure is necessary.

Once your data is loaded into LeveLink™, click the 'Level Data Correction' tab.

2.11.2. Selecting Corrections

On initial entry to the Level Data Correction tab, the data box and charts will be blank. In order to bring corrected data in from the Logged Data tabs, you must first choose the type of correction and averaging to apply. The choices are shown below.

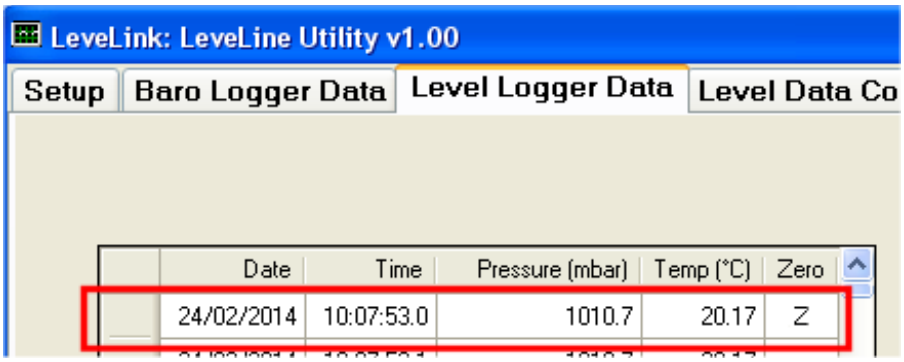


2.11.3. Baro Correction Overview

In the Baro Correction frame, you have a choice of 'None', 'Logged Zeros', 'Baro File' or 'Fixed'. If you do not want to correct for barometric pressure, select 'None'.

2.11.3.1. Logged Zeros Baro Correction

Logged zeros are pressures that were logged during manual deployment with either a QuickDeploy™ Key or a LeveLine® Meter **whilst the logger was out of the water**. These pressures represent the barometric pressure at the exact time of deployment (or the zero offset in the case of a vented logger) and can therefore be used to apply a zero offset to the level. When Level Logger Data has been uploaded, any record that is a Logged Zero, will appear with a corresponding 'Z' in the Zero column as shown in the example below.



Selecting the 'Logged Zeros' baro correction option will use these pressures to apply an offset to the data points. This offset will make the level read zero each time a logged zero point appears in the data. Subsequent data points will be offset by a corresponding amount thereby correcting them for the atmospheric pressure prevalent at the instant of deployment.

If your data was logged using a GAUGE (vented) type Level Logger, this is the only relevant Baro Correction option (other then 'None), and serves to zero any slight offset or zero drift in the Gauge type sensor.

2.11.3.2. Baro File Baro Correction

If your data was logged using an ABS (absolute) type Level Logger and you have an associated Baro Logger file loaded, the 'Baro File' option should be used. This will automatically associate the Water Level data and Baro data files and correct the water level for changes in barometric pressure.

If you chose this option, the barometric pressure data logged by the Baro Logger must coincide time-wise with the level data you are trying to correct.

2.11.3.3. Fixed Value Baro Correction

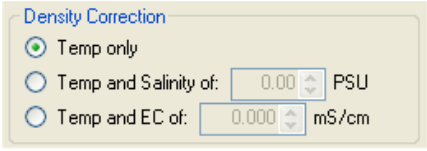
If your data was logged using an ABS (absolute) type Level Logger and you do not have an associated Baro Logger file loaded, you can apply a fixed barometric correction by ticking the 'Fixed' box and inserting a fixed barometric pressure. This option can also be used to correct for any zero offset present when using a Gauge (vented) type Level Logger.

2.11.4. Water Density Correction

When calculating the level of water based on water pressure, it is essential to know both the temperature and the salinity of the water in question. These two factors affect the density of the water and therefore the amount of pressure that water will exert on a pressure sensor at any given level.

If your data was logged using a -CTD Probe, actual salinity will be known so density correction for temperature and salinity will be automatically applied and the density correction options will be disabled.

If your data was logged with a standard Probe, you have the option to correct water density for water temperature alone or for both water temperature and salinity.



If you are taking level measurements in fresh, clean water, there is no need to correct for salinity so select 'Temp only'.

If you are taking level measurements in brackish or salt water and the salinity of the sample water is known, select 'Temp & Salinity' then input the salinity in Practical Salinity Units (PSU).

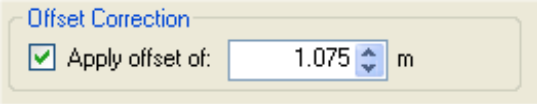
If you are taking level measurements in brackish or salt water and the specific EC (Electrical Conductivity) of the sample water is known, select 'Temp & EC' then input the specific EC in mS/cm^2 (corrected for 25°C). LeveLink™ will calculate the salinity based on the EC and use this to correct for water density.

2.11.5. Offset Correction

An installation offset is often required to be added to, or subtracted from the logged level data.

This offset should have been measured during installation and could, for instance, be the distance between the LeveLine® Logger and the surrounding ground level, the local sea level or the bottom of a river bed. See section 3.2.9 for further details.

To apply an offset to your data, tick the 'Apply offset of:' tick-box and enter the required offset.



If the water level is being referenced to some point above the LeveLine® Logger (such as the top of the borehole), the offset should be recorded as a negative number.

If the water level is being referenced to a point below the LeveLine® Logger, such as a river bed, the offset should be recorded as a positive number.

2.11.6. Data Averaging

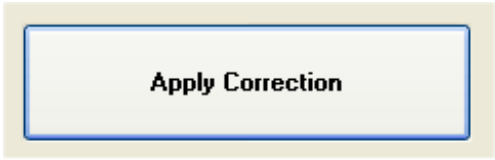
When the LeveLine® Logger logs data, there is no averaging applied. Each logged point is an instantaneous snapshot of temperature and pressure.

If you subsequently want to apply averaging to the logged data, to eliminate wave action for instance, tick the 'Average over:' tick-box and select the number of readings you want to include in the running average. When making this selection, bear in mind your logging rate.

If, for instance, your logging rate was every ten seconds, by averaging over 9 readings, you are applying a running average of 80 seconds to your data.

2.11.7. Applying Corrections

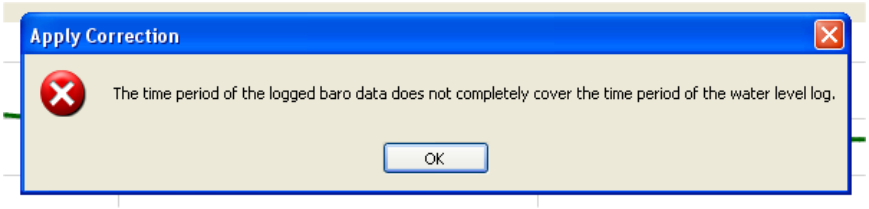
Once you have selected all the corrections you want to apply to your data, click the 'Apply Correction' button.



LeveLink™ will take the data loaded into 'Level Logged Data' and 'Baro Logged Data' (if applicable) tabs, apply the corrections you have chosen, then re-display the corrected data.

If you have chosen to apply Baro correction from a 'Baro file', the barometric pressure data logged by the Baro Logger must coincide time-wise with the level data you are trying to correct.

If LeveLink™ can not match the two files up, an error message will be displayed.



If this occurs, you must either use an appropriate Baro Log file or choose an alternative method of Baro correction.

2.11.8. Applying Multiple Corrections

Each time you click the 'Apply Correction' button, the corrections you have selected are applied to the raw data from scratch.

If you have already applied corrections and subsequently change one of the correction parameters, clicking 'Apply Correction' will remove all corrections previously applied then re-apply the newly selected corrections to the original raw data.

2.11.9. Exporting Corrected Data

Once data corrections have been applied, the correct data can be exported as a spreadsheet file or a Google™ Earth file. The original raw data files are not affected and can therefore be used repeatedly with with various types of correction applied.

3. LeveLine® Deployment

Prior to deployment of any LeveLine® Logger, be sure to connect it to either a PC running LeveLink™ software or to a LeveLine® Meter and to set up your desired logging start time, duration and logging rate. **If you do not set the LeveLine® Logger up, it will not log any data!**

3.1. Identifying the LeveLine® Type and Depth Rating

It is extremely important to identify your LeveLine® Probe depth rating prior to deployment. Deploying a Baro Logger under water will cause the pressure sensor to be overloaded and damaged. Similarly, deploying a water level Logger deeper than its maximum rating will cause overload damage.

To identify your LeveLine® Probe's depth rating, remove the black end cap, or in the case of the -CTD version, the black nose sleeve, and look at the label fitted onto the end of the Logger. The label will show the Logger type (ABS or Gauge) and maximum depth rating (in meters).

After identifying your Probe's type and depth rating, replace the end cap or nose sleeve and follow these simple rules:

- Never deploy a Baro Logger below the surface of the water.
- Never deploy a water level Logger deeper than its maximum rating.
- Never deploy a water level Logger where the water is liable to freeze.
- If deploying a Gauge type Logger, always use a vented cable.

3.2. Deploying the ABS and Baro Versions

The absolute (ABS) and Baro versions of the LeveLine® Probes are extremely easy to deploy as they do not require a vented cable.

ABS and Baro loggers are usually used in conjunction with one another.

Level data obtained from the submerged ABS logger is corrected for changes in atmospheric pressure in LeveLink™ by comparison to barometric pressure logged during the same period with a Baro Logger.

On a site where there are several ABS loggers deployed, there is only need for one Baro logger.

The diagram to the right shows a typical borehole installation with the ABS logger submerged and the Baro logger suspended above the maximum water level line.

Please note, in this case the well or borehole cap must be ventilated in order to allow the Baro logger to register the true barometric air pressure.

Important: Always install the LeveLine® Loggers vertically with the suspension cap at the top as shown in the diagram above. Water level measurements are made at the row of holes positioned around the bottom of the black end cap/sleeve. Use these holes as a reference point for measuring deployment offsets.

3.2.1. Deployment in Open Water

If the Probe is to be deployed in open water (i.e. a river, lake or the sea), a length of plastic pipe should first be mounted, then the Probe should be suspended within the pipe so it is always under water, but not on the bottom where it could become buried by silt. This will protect the Probe from currents, wave action, and debris.

If required, the Baro logger can also be suspended in the same pipe, provided the cap is vented and the Baro logger is suspended above the maximum water level line.

3.2.2. Choice of Suspension Cable

It is important to use a non-stretch cable to suspend the submerged logger. If the cable stretches after deployment, a corresponding level change will be recorded. Braided stainless steel or Kevlar is recommended.

It is advisable to pull test whatever cable you have chosen to ensure it will not stretch after installation.

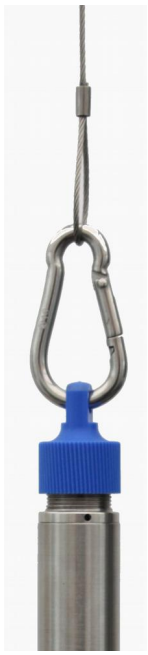
3.2.3. Deployment Depth

Baro loggers must not be submerged! All other Probes must not be submerged below twice their rated depths. If any Probe is submerged past this limit, the pressure sensor will burst and will require replacing. Damage of this kind is not covered by your warranty.

Ideally, the water level Probe should be positioned where it will remain submerged at all times, but never to a greater depth than twice its depth rating.

3.2.4. Deploying the ABS Logger

- Measure the distance from the proposed suspension point to the estimated lowest surface level of the water.
- Cut a length of cable approximately one meter longer than this measurement in order to ensure the logger will always remain submerged.
- Secure the cable to the logger cap and the suspension point, preferably using a swaged stainless steel ferrule and a carabiner clip as shown.
- If the logger has not been programmed to start logging at some time in the future, start the logger now using either a LeveLine® QuickDeploy™ Key, a LeveLine® Meter or a PC running LeveLink™ software.
- When you are certain logging has started, screw the logger firmly into the logger cap and lower it into the water.



NEVER SUBMERGE A LOGGER WITHOUT EITHER A SUSPENSION CAP OR CABLE FITTED
Damage caused by water ingress through the socket is not covered by your warranty

3.2.5. Deploying the Gauge (Vented) Version

Deployment of the gauge or vented version of the LeveLine® logger is similar to the ABS version, but instead of a simple suspension wire, a vented cable must be used.

The LeveLine® Loggers are designed to connect to a LeveLine® Meter or a third party telemetry device using a LeveLine® Extension Cable. The LeveLine® Extension Cable features high-pressure metal connectors, which incorporate several O-ring seals at the Logger end. Prior to first connection, the seals must be lubricated using the silicone grease provided.

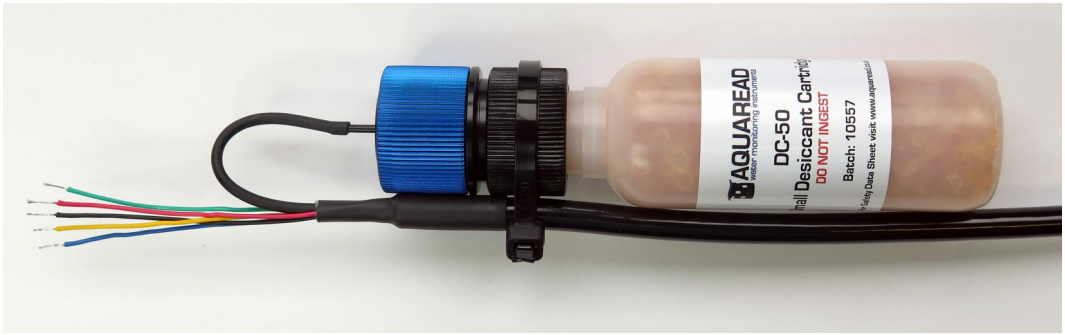
Apply a generous smear of grease to the connector O-rings situated just inside the moveable retaining collar on the plug. Be careful not to get any grease inside the connector near the gold contacts. A small smear of grease should also be applied to the thread on the Logger to allow easy tightening of the collar.

To connect the Extension Cable to the LeveLine® Logger, align the spot on the LeveLine® Logger with the ◄**AQUAREAD** logo on the plug body, then press the plug into the Logger and tighten the retaining collar fully. **DO NOT TWIST THE CONNECTOR BODY WITH RESPECT TO THE LOGGER**. Once the LeveLine® has been connected to the Extension Cable, the LeveLine® Meter or telemetry device can be connected along with a desiccant housing and desiccant cartridge.

3.2.6. Fitting a Desiccant Housing and Cartridge

When installing a gauge (vented) type LeveLine® logger with a vented cable, **the free end of the cable must be positioned above the maximum expected water level.** It is also essential to fit a desiccant housing and cartridge to the free end of the cable in order to prevent any moisture entering the cable or logger.

If you intend to use a telemetry device with a permanent connection to the cable, a Telemetry Cable Desiccant Housing (Part No. EX-TDH shown below) is required along with either a DC-50 or DC-100 Desiccant Cartridge.



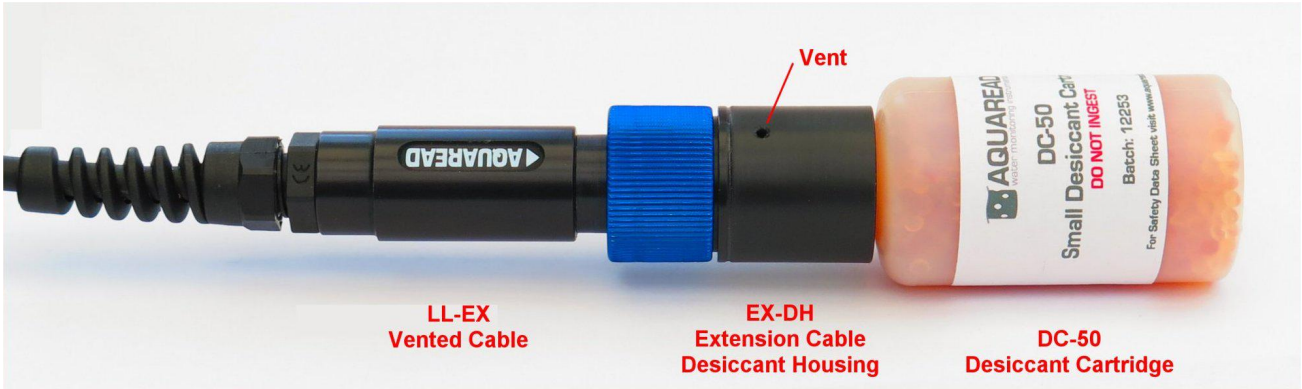
If the end of the cable is to be used only as a vent for the logger, an Extension Cable Desiccant Housing (Part No. EX-DH) is required along with either a DC-50 or DC-100 Desiccant Cartridge. See the photograph at the bottom of the next page.

The desiccant used within the Aquaread® Desiccant Cartridges is a non-toxic, self-indicating synthetic amorphous silica designed to change colour as it absorbs moisture from orange to clear. Desiccant Cartridges are available in two sizes.

The choice of small (DC-50) or large (DC-100) Desiccant Cartridge is dependant upon the humidity at the deployment site and the expected maintenance frequency. If the deployment site is humid or the time between maintenance visits is expected to be long, the large (DC-100) Desiccant Cartridge is recommended.

The time taken for a fresh, dry Desiccant Cartridge to go from orange to clear (i.e. become fully saturated) is dependant upon site conditions. Regular maintenance checks should be made on the installation and the Desiccant Cartridge should be replaced or regenerated **before it is completely saturated (clear).**

To fit an Extension Cable Desiccant Housing (Part No. EX-DH), simply screw the free end of the Extension Cable onto the Housing as shown in the photograph below. Once fitted, remove the cap from your chosen Desiccant Cartridge and screw the Cartridge into the Housing. Do not over-tighten the Cartridge.



The two vent holes located in the Desiccant Housing allow the pressure in the logger and cable to remain at ambient atmospheric. Air is allowed to vent slowly in and out of the assembly via an internal waterproof membrane. Any moisture that develops within the cable or logger due to condensation is absorbed by the Desiccant Cartridge. **Do not block the vent holes or allow the housing to sit in water.**

3.2.7. Regenerating Desiccant

When the desiccant in a Desiccant Cartridge has absorbed all the moisture it can and has changed from orange to clear, it can be regenerated and reused by a simple drying process.

Spread the desiccant crystals evenly on a suitable baking sheet and bake in an oven between 100°C and 200°C for around an hour or until the colour has changed from clear back to deep orange. After being allowed to cool, the crystals can be replaced in the Desiccant Cartridge and reused.

3.2.8. Gauge (Vented) Version Zero Offset

Gauge (vented) loggers should, in theory, always measure a pressure of zero when not submerged. In practice, however, this is rarely the case due to mechanical and electronic drift, short term temperature differentials between the pressure and temperature sensors and mechanical stresses.

With the LeveLine Gauge type loggers, any zero offset can be easily removed in LeveLink using the Baro Correction feature detailed in section 2.11.3 Deploying the logger with a QuickDeploy™ Key will make this process fully automatic.

3.2.9. Recording the Deployment Offset

If an offset is required for post correction, measure the distance between the bottom of the Logger and the desired reference point now.

This could be the surrounding ground level or the top of the mounting pipe, local sea level or the bottom of a river bed.

If the water level is being referenced to some point above the logger (such as the top of the borehole), the offset should be recorded as a negative number.

If the water level is being referenced to a point below the water surface, such as a river bed, the offset should be recorded as a positive number. This offset can be input into the LeveLink™ software and automatically applied to the recorded data along with barometric pressure and water density corrections.

3.3. Deploying the Baro Logger

- Measure the distance from the proposed suspension point to the estimated highest surface level of the water.
- Cut a length of cable to a length that will ensure the Baro logger will always remain **above** the maximum water level.
- Secure the cable to the logger cap and the suspension point, preferably using a swaged stainless steel ferrule and a carabiner clip as shown above.
- If the Baro logger has not been programmed to start logging at some time in the future, start the Baro logger now using either a LeveLine® QuickDeploy™ Key, a LeveLine® Meter or a PC running LeveLink™ software.
- When you are certain logging has started, screw the Baro logger firmly into the logger cap and lower it into the mounting tube, ensuring it is well above the water level.

3.4. Using the LeveLine® QuickDeploy™ Key

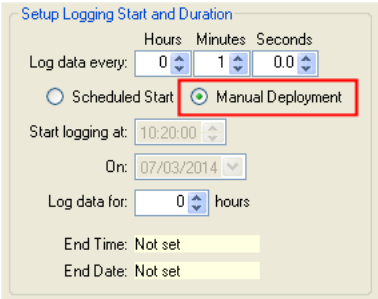
The QuickDeploy™ Key is a simple plug-in device which allows a pre-programmed logging scheme to be started at the exact instant of deployment. It also embeds a zero depth reference marker in the logged data in order to allow absolute depth measurement from the start and carries out an instant check on the battery and memory levels.

3.4.1. Setup Prior To Deployment with a QuickDeploy™ Key

If you intend to make use of a QuickDeploy™ Key, it is essential to set the LeveLine® Logger up first by connecting it to a PC running LeveLink™ software.

Using the LeveLink™ software, set the Logger's clock, site ident, deployment position, logging rate, logging duration and any event triggering you want.

Next, set the Manual Deployment option as shown here. The Logger is now ready for deployment using a QuickDeploy™ Key.



If the Logger has been previously setup with a scheduled start, which is still in the future, using the QuickDeploy™ Key will override the scheduled start.

3.4.2. Deploying the LeveLine® Using the QuickDeploy™ Key

When you have completed your suspension cable installation as described in section 3.2.4, align the LED on the QuickDeploy™ Key with the alignment spot on the LeveLine® Logger and plug it in as shown in the photograph.

The LED on the QuickDeploy™ Key will immediately flash to indicate the Logger's status in accordance with the table below.

1 flash/second	Logger successfully deployed and logger is healthy.
2 flashes/second	Logger successfully deployed but Logger battery has less than 10% capacity remaining.
3 flashes/second	Logger successfully deployed but Logger memory has less than 10% capacity remaining.
LED does not flash	Battery in QuickDeploy™ Key is dead. Replace the battery.

This information is also printed on the QuickDeploy™ Key.

It is inadvisable to proceed with deployment if the Logger battery or memory is low, as indicated by multiple LED flashes. This could result in data loss.

If you receive a single flash once per second, this indicates the Logger has been successfully deployed, has logged its first data point and can now be attached to its suspension cable and lowered into position.

Simply unplug the QuickDeploy™ Key and proceed with your installation. Do not leave the Key plugged in any longer than necessary as this will quickly deplete the Key's battery.

3.4.3. Using the QuickDeploy™ Key After Deployment

As well as initiating logging, the QuickDeploy™Key also embeds a zero marker in the logged data. The data associated with this zero marker can be used in the LeveLink™ software as a barometric pressure reference during data correction for atmospheric pressure. See section 2.11.3.1 for further details.

At any time during the Logger's deployment, a QuickDeploy™ Key can be re-connected to the Logger to check battery and memory status and to embed further zero markers. This is particularly useful if you are not simultaneously logging barometric pressure at the same site but want to keep track of the barometric pressure on say, a daily basis.

3.4.4. QuickDeploy™ Key Battery Replacement

The QuickDeploy™ Key contains an integral 12V alkaline battery (type 23A, MN21, MS21, A23 or VA23GA). If the LED on the QuickDeploy™ Key fails to flash when plugged into a Logger, replace the battery. This is accessed by unscrewing the blue plastic housing from the metal body of the Key and is self explanatory.

3.5. Deploying the LeveLine® Mini and Mini-CTD

The advice for deploying the Mini versions is largely the same as that for deploying the full size versions. Please refer to the previous section for more details.

Because the Mini Probes are designed solely for use with remote logging or telemetry systems, they must always be deployed with a power/communication cable. When deploying a Mini Gauge version, a vented cable must be used.

4. LeveLine® Meter

The LeveLine® Meter has four main functions.

- Displaying live data from any model of LeveLine® Logger.
- Allowing on-site setup and deployment of any model of LeveLine® Logger.
- Allowing on-site, in-situ retrieval of data from up to 300 separate LeveLine® Loggers for later download to a PC running LeveLink™ software.
- Calibration of the EC function on -CTD version Probes.

When being used in conjunction with a Meter, all LeveLine® Logging Probes are referred to as 'Probes' rather then 'Loggers' in order to retain the naming conventions seen in other models of Aquaread® Meters.

4.1. The LeveLine® Meter and the Environment

The LeveLine® Meter is designed to be used outdoors and is rated to IP67, that is to say it is waterproof but it **is not** designed for submersion. In order to prevent accidental dunking or loss, a lanyard is supplied.

Please note that the socket on the LeveLine® Meter is only waterproof when the associated plug is fitted. Without the plug fitted, water can enter the socket. Damage caused by water ingress through the socket is not covered by your warranty.

You may notice a small hole on the rear of the unit near the top. This is a waterproof vent for the internal barometric sensor. **Do not poke anything in this hole!** Doing so will cause major damage to the vent's waterproof membrane and invalidate your warranty.

4.2. Meter Battery Installation and Care

The LeveLine® Meter requires five AA size batteries. To install the batteries, loosen the two screws on the centreline of the rear of the meter and remove the battery compartment lid. Following the battery polarity markings inside the battery compartment, insert five AA cells then replace the compartment lid and tighten the screws.

4.2.1. Choice of Battery Type

Alkaline or rechargeable batteries may be used, but never mix battery types in the meter. If you choose to use rechargeable batteries, we recommend *Energizer* 2500mAh (or greater) Nickel-Metal Hydride cells, which are widely available.

If the Meter is to be out of use for a long period, remove the batteries to prevent damage due to possible leakage.

4.2.2. Battery Life

A set of fresh alkaline cells will give over 25 hours continuous use in the LeveLine® Meter. A fully charged set of 2500mAh NiMH cells will give up to 50 hours continuous use.

4.2.3. Battery Charging

During the charging process, batteries generate heat and vent gasses, and must never be charged inside a sealed unit. Because the LeveLine® Meter is a sealed unit, we do not allow charging in-situ. Batteries must be removed and charged with a suitable battery charger outside the Meter. We recommend the use of one of the *Energizer* range of NiMH chargers.

4.2.4. Battery Condition Icon

On all the main LeveLine® Meter screens, a battery condition icon is displayed in the top left corner. The icon shows full when the batteries are fresh, and gradually empties as the batteries are used. When the batteries need replacing, the empty battery icon will flash on and off. If you ignore this, the Meter will automatically switch itself off when the battery voltage becomes too low for reliable operation.

When using rechargeable batteries, the battery icon will not show completely full, even with freshly charged cells. This is due to the fact that rechargeable batteries are only rated at 1.2V per cell compared to 1.5V per cell for alkaline batteries. This indication does not affect battery life. The icon will simply sit at the ¾ full mark for a longer period of time.

4.2.5. Battery Saver Functions

The LeveLine® Meter is designed to switch off automatically if you do not touch any of the keys for 30 minutes.

The display on the LeveLine® Meter incorporates a white backlight to improve visibility in low-light conditions. As on a mobile phone, the backlight switches on each time a key is pressed and stays on at full brightness for a short time before fading to half brightness then switching off.

During normal operation, if you want to activate the backlight without changing the Meter function, simply press the **ESC** key.

4.3. Overview of the Operating System

The operating software in the LeveLine® Meter has been designed for simple, intuitive use.

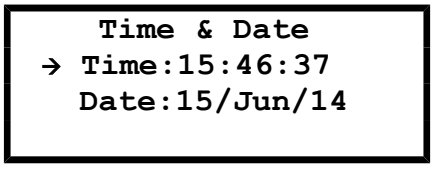
If you are used to operating a mobile phone or programming audio/visual equipment using a remote control, you should feel at home with the familiar up/down left/right arrow shaped navigation keys and central **OK** key.

The tree structure behind the **MENU** key should also be very familiar. Each item on the menu leads to a sub menu and then either on to further menus or final choices. Each branch of the menu system is navigated using the arrow keys. At each point, selections can be made by either pressing the **OK** key or the right arrow key.

To reverse along a branch of the menu system, use the **ESC** (escape) key or left arrow key. After a short time, you should be able to navigate around the entire menu system at speed using just the four arrow keys. If, at any time, you leave the Meter in one of the sub-menu screens, it will automatically back out to the main operating screen after 15 seconds.

4.4. Initial Switch On and Clock Setup

To switch the meter on or off, briefly press the red key. **Do not hold it down.** The meter contains a real-time clock. When switching on for the first time, you must set the clock. The first screen you will see is the Time & Date Setting Screen.

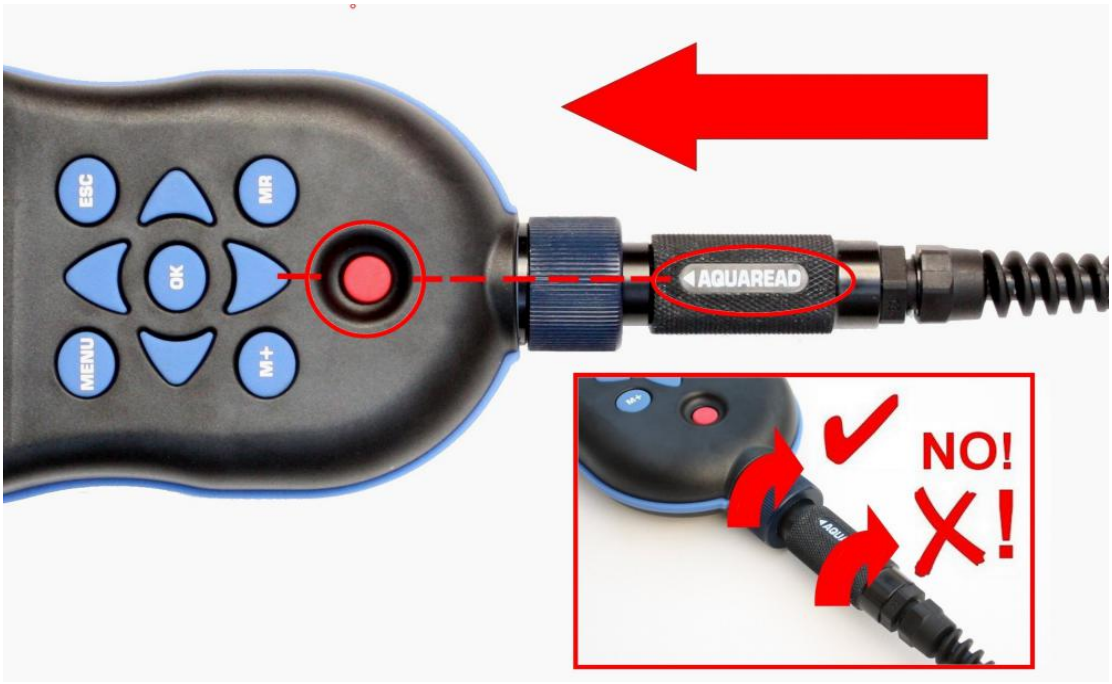


To set the time and date, use the arrow keys to move the cursor around the screen. Use the up and down arrow keys to adjust values. When the time and date are correct, press the **OK** key. Don't worry if you make a mistake first time round. You can easily get back to this screen later by hitting the **MENU** key followed by **Probe & Meter Setup** then **Setup Meter.**

4.5. Connecting to a LeveLine® Level or Baro Logging Probe

The LeveLine® Loggers are designed to connect to the LeveLine® Meter using purpose made cables, which feature rugged metal connectors.

4.5.1. Connecting the Cable to the Meter



Always ensure the LeveLine® Meter is switched off prior to connecting or disconnecting a Logger. Align the ◄**Aquaread**® logo on the black plug body with the red on/off switch on the LeveLine® Meter, then press the plug into the socket and tighten the retaining collar.

DO NOT TWIST THE CONNECTOR BODY WITH RESPECT TO THE METER.

4.5.2. Connecting the Cable to a Logger

The LeveLine® Extension Cable features a high-pressure titanium connector at the Logger end, which incorporates several O-ring seals. Prior to first connection, the seals must be lubricated using the silicone grease provided.

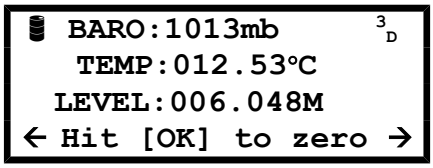
Apply a generous smear of grease to the connector O-rings situated just inside the moveable retaining collar on the plug. Be careful not to get any grease inside the connector near the gold contacts. A small smear of grease should also be applied to the thread on the Logger to allow easy tightening of the collar.

To connect the Extension Cable to the LeveLine® Logger, align the spot on the LeveLine® Logger with the ◄**AQUAREAD** logo on the plug body, then press the plug into the Logger and tighten the retaining collar fully. **DO NOT TWIST THE CONNECTOR BODY WITH RESPECT TO THE LOGGER**

Once a Logger is connected to the LeveLine® Meter, switch the Meter on by briefly pressing the red on/off switch. The LeveLine® Meter should detect the Logger and automatically display the Logger's serial number, firmware revision and pressure rating.

4.6. Taking Measurements

After a few seconds, the Meter will automatically start to display live readings along with the current GPS status. The initial data screen for the LeveLine® Meter in conjunction with a Level Logging Probe is shown below. If connected to a Baro Logger, lines three and four will be blank.

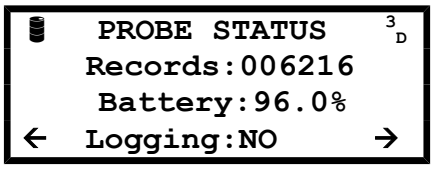


When connected to a Level Logging Probe, the BARO value on the top line is derived from the Meter's internal barometric sensor. When connected to a Baro Logger, the BARO value is derived from the barometric sensor in the Logger.

When connected to a Level measuring Probe, the [OK] key can be used to zero the level reading, as indicated on the bottom line of the display. Pressing [OK] will apply an offset to the current level reading to make it read zero on the Meter. All subsequent level readings on the Meter will be subject to this offset until the Meter's power is cycled or the level is zeroed again.

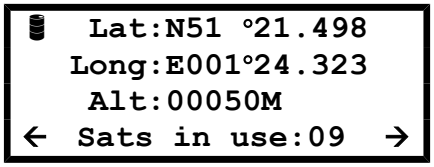
This means that subsequent levels may be either positive or negative with respect to the depth at which the reading was zeroed. Zeroing the level in this way does not have any affect on the Logger or the logged data. It is a function of the Meter only.

Left/right arrows at the bottom corners of the screen indicate further data screens are available. To access these screens, simply press either the left or right arrow keys. Any value that is out of range or unavailable will be displayed as dashes. The other screens available are shown below.

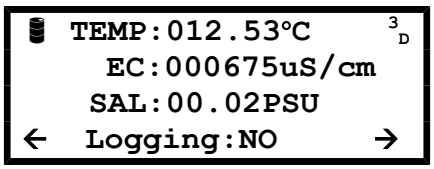


Probe Status Screen

When connected to a Mini version, the values displayed on this screen will not be valid as there is no memory, battery or logging facility.



Position Screen



EC/Salinity Screen

Please note, the EC/Salinity screen will only be displayed if the Meter is connected to a -CTD type Probe.

4.7. What Does It All Mean?

The table below explains the screen abbreviations.

Prefix	Meaning	Units
BARO	Barometric Pressure	mb or mmHg*
TEMP	Probe Temperature	°C or °F*
LEVEL	Level of the probe below the surface of the water	meters or feet*
EC	The electrical conductivity of the water	µS/cm**
SAL	Salinity	PSU (equivalent to ppt)
Readings	Number of readings in the Probe's memory	N/A
Battery	Battery capacity remaining	%
Logging	Indicates if the Probe is logging data or not	Yes or No
Lat	Latitude	Degrees & Mins
Long	Longitude	Degrees & Mins
Alt	Altitude of the Meter above Sea Level	meters or feet*
Sats in use	The number of satellites the GPS is currently using	N/A
$^{3}_{D}$	GPS Receiver status (see below)	$^{3}_{D}$, $^{2}_{D}$ or $^{A}_{Q}$

* These items can be selected as alternative units of measurement. See 4.9.1.
** EC can be displayed as absolute or corrected for temperature. See section 4.9.3.

4.8. GPS Reception

The LeveLine® Meter contains a built-in GPS receiver and antenna. The antenna is situated at the top of the case, just behind the Aquaread® Logo. For optimum signal reception, the antenna must be able to 'see' a reasonably large amount of the sky. **The GPS receiver will not work indoors or when shielded from the sky by any solid structure.**

After switch-on, the GPS receiver will automatically start to search for satellites. During this phase an '$^{A}_{Q}$' character will be shown at the top right of all the screens. This means the GPS receiver is **acquiring** satellite data.

As soon as three satellites are acquired, two dimensional position (no altitude) will be calculated and a '$^{2}_{D}$' character will be shown at the top right of all the screens.

Once a fourth satellite is acquired, altitude will be calculated and a '$^{3}_{D}$' character will be shown at the top right of all the screens. With a good view of the sky, position should be calculated within ninety seconds of switch-on. To see your geographic position and the number of satellites in use, use the left or right arrow keys to scroll to the Position screen.

If you switch the meter on indoors, then carry it outside after several minutes, there may be a considerable delay in acquiring satellites. In this case, switch the meter off, then back on again to reset the acquisition process.

4.9. Meter Setup

To alter the way the LeveLine® Meter displays readings, press the **MENU** key to get to the Main Menu, then choose **Probe & Meter Setup** followed by **Setup Meter.** The Settings Menu for the Meter will be displayed.

```
     Meter Setup
→ Measurement Units
   Meter Time & Date
   EC Correction
```

4.9.1. Setting Units of Measurement

From this screen choose **Measurement Units**. The Units Menu will be displayed. Remember, you can use just the arrow keys to navigate through the branches of the menus. You don't need to press **OK** or **ESC** at each level.

```
  Measurement Units
→ Temp:°C
   Baro:mb
   Level:Metres
```

On the Measurement Units screen, you have a choice of which units you want to adjust. Choose the first line if you want to adjust temperature units. Choose line 2 if you want to adjust barometric pressure units. Finally, line 3 will allow you to adjust the units for level.

Moving the cursor right onto the first line will allow you to choose between displaying temperature in degrees Centigrade or Fahrenheit. Use the up/down arrow keys to make your selection.

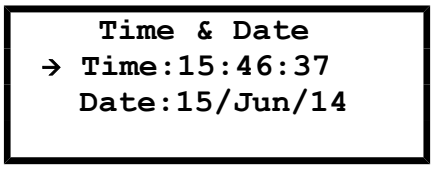
Moving the cursor right onto the second line will allow you to choose between displaying barometric pressure in millibars (mb) or millimetres of mercury (mmHg). Use the up/down arrow keys to make your selection.

Moving the cursor right onto the third line will allow you to choose between displaying the level in Metres or Feet. Use the up/down arrow keys to make your selection.

4.9.2. Setting the Meter Time & Date

Setting the Meter's time and date correctly is extremely important as the clock in the Meter is used to set the clock in the LeveLine® Logger.

From the Meter Setup menu, choose **Meter Time & Date.**



To set the time and date, use the arrow keys to move the cursor around the screen. Use the up and down arrow keys to adjust values. When the time and date are correct, press the **OK** key.

4.9.3. Setting the EC Correction

When connected to a – CTD Probe, this setting allows you to choose how the Meter displays Electrical Conductivity.

There are three options. EC can be displayed as 'Absolute EC' without any temperature correction [ABS EC], as 'Specific EC' referenced to 20°C [Ref 20°C] or as 'Specific EC' referenced to 25°C [Ref 25°C].

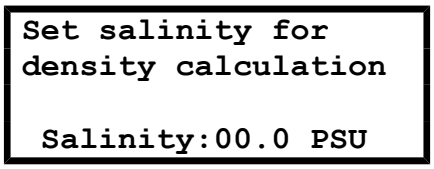
4.9.4. Setting Salinity

The basic LeveLine® Loggers simply output temperature and water pressure. In order to translate these values into actual water levels for display on the Meter, the data must be corrected for water density.

Water density is a function of temperature and salinity. The Meter already knows the water temperature, but in order to take salinity into account, you must input a salinity value manually.

This salinity setting is ignored when the Meter is connected to a -CTD type Probe, as live salinity data is already available.

To set a manual salinity value, press the **MENU** key to get to the Main Menu, then choose **Probe & Meter Setup** followed by **Set Salinity.** The salinity setting screen will be displayed.



Use the up/down arrow keys to input the salinity of the sample water in Practical Salinity Units.

If you have the Meter connected to a – CTD Probe, which measures EC and salinity directly, this function will be redundant and the **'Set Salinity'** option on the menu will be replaced by a **'Calibrate EC'** option.

4.10. Calibrating the Electrical Conductivity Cell on - CTD Probe Models

4.10.1. EC Calibration Standards

EC calibration is always carried out at a single point. There is a choice of two Aquaread® calibration standards, or you can use any third party calibration standard value between 100µS/cm and 99,999µS/cm.

The Aquaread® standards are: Aquaread® RapidCal™ (EC value 2570µS/cm at 25°C) for general use, and Aquaread® SC-35 (EC value 53,065µS/cm at 25°C), which is specifically for use when measuring EC and salinity in sea water.

The calibration solution value you use to calibrate EC should always be chosen to be as near to the readings you expect to see in the field as possible.

If you are not sure what values to expect, RapidCal™ is a good choice as this will give reasonably accurate readings across a wide range of EC values.

For best results, calibrate as close to 25ºC as possible. The Probe will compensate for temperature variation in the Calibration Standard during calibration.

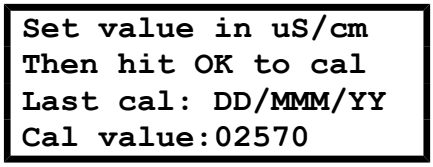
4.10.2. Recognising the EC Cell

The -CTD Probes all have an elongated nose sleeve covering the EC cell contacts.

The black plastic nose sleeve (shown removed on the right of the photo) forms an integral, working part of the Probe's EC measurement system, and MUST be fitted during calibration and measurement for correct operation.

4.10.3. EC Calibration Technique

1. Remove the nose sleeve from the Probe, wash the EC cell and the sleeve in clean water, dry thoroughly, then replace the nose sleeve.
2. Drop the Probe into a calibration bottle filled with EC Calibration Standard and agitate to remove any air bubbles from inside the sleeve.
3. **Ensure the liquid level is above the top row of holes in the nose sleeve. Low liquid level will result in erroneous EC calibration.**
4. Watch the temperature and EC readings on the Meter and wait until they are completely stable.
5. Ensure the temperature of the solution is between 5ºC and 40ºC (41ºF -104ºF).
6. On the Meter, press 'Menu' key then select 'Probe & Meter Setup' followed by 'Calibrate EC'. The following screen will be displayed:



The third line on the screen tells you the last time the EC was calibrated. The fourth line tells you the last calibration standard used.

7. Using the four arrow keys to navigate and select, enter the EC Cal value of your calibration solution at 25ºC. If using Aquaread® RapidCal™, this value should be 02570.
8. Press the 'OK' key.

If the software detects a problem, an error message will be displayed. If an error message is displayed, take remedial action and try again.

When calibration is complete, a message will be displayed indicating that the calibration was successful and a Cell Constant will be displayed.

After calibration, rinse the Probe in fresh water.

4.10.4. EC Cell Constant

The EC cell constant is an indication of the health of the EC cell. Nominally, the EC cell constant should be around 1.25. This can vary with different calibration standard values and calibration temperatures.

If the EC cell constant is reported above 2.00 or below 0.5, carefully clean the EC cell contacts and the inside of the nose sleeve. Also check your calibration solution is fresh and that you have input the quoted value (at 25ºC) during calibration.

4.10.5. Frequency of EC Calibration

Ideally, EC calibration should be carried out regularly based upon the levels of soiling the Probe experiences.

On a regular basis, thoroughly clean the inside of the nose sleeve and the four metal EC contacts situated in the EC cell with a soft cloth or toothbrush and non-abrasive detergent. **Never use solvent or alcohol based products to clean the EC cell**. After cleaning, replace the nose sleeve and re-calibrate EC.

4.11. Probe Setup (applicable to logging versions only)

Prior to deployment of any LeveLine® Logger Probe, it is essential to set up your desired logging rate, logging start time and duration. **If you do not set the LeveLine® Logger up, it will not log any data!**

LeveLine® Probes can be setup and deployed entirely from the Meter. Each time a setup command is sent to the Probe from the Meter, an 'ACTION SUCCESSFUL' or 'ACTION FAILED' message will be displayed. If you receive repeated 'ACTION FAILED' messages, please refer to the troubleshooting section at the end of this manual. If you do not have a Probe connected to your Meter, you will not be able to access any of these screens.

4.11.1. Probe Clock Setup

The clock in the Probe is setup by synchronising it to the clock in the meter. To setup the Probe's clock, first ensure the Meter's clock is correctly set. See section 4.9.2

When you are certain the Meter's clock is correctly set, press the **MENU** key to get to the Main Menu, then choose **Probe & Meter Setup** followed by **Sync Probe Clock.** The Probe time and date screen will be displayed.

```
  Probe Time & Date
→ Time:15:46:37
  Date:15/Jun/14
[OK] = Sync to Meter
```

On entry to this screen, the Probe's current time and date will be displayed. To synchronise the clock in the Probe with the Meter's clock, press the [OK] key. After successful setup of the Probe's clock, the 'ACTION SUCCESSFUL' message will be displayed.

Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], your revised settings will not be transferred to the Logger.

4.11.2. Logging Rate Setup

To set up the Probe's logging rate (time interval between logged points), press the **MENU** key to get to the Main Menu, then choose **Probe Deployment** followed by **Set Rate & Events.** The Probe Logging Rate screen will be displayed.

```
 Setup Logging Rate
      [HHH:MM:SS.S]
→ Rate:000:10:00.0
  Setup Events
```

The format for the logging rate is indicated on the second line of the display. The example above shows a logging rate (time interval) of 10 minutes.

The logging rate can now be adjusted using the arrow keys. Press the right arrow key to move the cursor to the hours [HHH] setting the use the up/down arrow keys to adjust the value. When hours have been set, move the cursor to the minutes value by pressing the right arrow key. Follow this procedure to set seconds and fractions of seconds.

When you have setup the desired logging rate, press the OK key to transfer the setting to the Logger. After successful setup of the logging rate, the 'ACTION SUCCESSFUL' message will be displayed.

Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], your revised settings will not be transferred to the Logger.

Different models of LeveLine® Loggers have different permissible logging rates.

- Titanium LeveLine® Loggers can be set up to log data as fast as ten time per second (log data every 0.1 second) and as slow as once every five days (120 hours).
- LeveLine® ECO Loggers can be set up to log data as fast as five time per second (log data every 0.2 second) and as slow as once every five days (120 hours).
- LeveLine® BARO Loggers can be set up to log data as fast as once per minute and as slow as once every five days (120 hours).

If you try to send an invalid logging rate to the Probe, the 'ACTION FAILED' message will be displayed and the Probe's logging rate will remain unaltered.

It is advisable to choose the slowest logging rate that your application can comfortably support. This is for two reasons: battery life and memory capacity. If you choose an extremely fast logging rate, the Logger's memory will fill up very quickly and you will have massive files to handle when you come to download and analyse your data.

Also, your battery will be depleted quickly. For example, at a logging rate of 0.2 seconds, the LeveLine® will be logging 18,000 points per hour. This will obviously deplete the available memory extremely quickly.

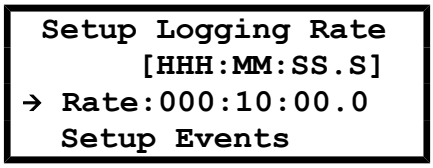
Also, unless you are monitoring live pumping operations or similar dynamic events, water levels and barometric pressures tend to alter reasonably slowly. For this reason, level logging rates between 1 and 15 minutes, and barometric pressure logging rates between 15 minutes and 1 hour are normally recommended.

Using these rates will result in reasonably sized data files and many years battery life. For further details concerning battery life, see section 1.3

4.11.3. Event Logging Setup

A useful feature of the LeveLine® Loggers is the ability to automatically increase the logging rate if rapid changes in either level or temperature/salinity are detected. Using this feature, memory can be saved by using a long logging interval (say several hours or more), but any rapid changes will be logged in full detail.

To set up the Probe's event logging settings, press the **MENU** key to get to the Main Menu, then choose **Probe Deployment** followed by **Set Rate & Events.** The Probe Logging Rate screen will be displayed.



Move the cursor down to 'Setup Events' and press the right arrow key or [OK]. The Setup Events screen will be displayed.

```
   Setup Events
→ Rate:000:01:00.0
Level +/-:00.100M
 Temp +/-:05.0°C
```

Using the cursor keys, set the rate (time interval) at which the event should be monitored. This value must be more regular than the normal logging rate. In the example above, the level and temperature will be monitored every minute.

Next set the trigger point for the event logging, in other words, the amount each value must change from the previously logged value in order to be logged.

So, in the example above, the level and temperature will be monitored every minute, but will only be logged if the level varies by more than 10cm from the previous logged value or the temperature varies by more than 5.0°C from the previously logged value.

When using a -CTD version, the Temperature event is replaced by a Salinity event. This is extremely useful when conducting salt water intrusion studies in coastal regions.

Finally, as with all settings, once the event logging criteria have been set up, transfer the settings to the Logger by pressing the OK key.

After successful setup of the event logging, the 'ACTION SUCCESSFUL' message will be displayed. Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], your revised settings will not be transferred to the Logger.

4.11.4. Deployment Site Ident Setup

To setup the Probe's Site Ident (a unique 16 character site identifier), press the **MENU** key to get to the Main Menu, then choose **Probe Deployment** followed by **Set ID & Position.**

The Set ID & Position screen will be displayed.

```
 Set ID & Position
 [Use arrow keys]
→ ID:Borehole 1
  View/Sync Position
```

The sixteen characters to the right of the 'ID:' label are the current site ident loaded into the connected Logger.

To alter the Site Ident, input the new site name (up to sixteen characters) using the up/down and left/right arrow keys.

As with all settings, once the new site ID has been setup, transfer the data to the Logger by pressing the OK key. If you press the [ESC] key from this screen, your revised settings will not be transferred to the Logger.

After successful setup of the event logging, the 'ACTION SUCCESSFUL' message will be displayed. Use the [ESC] key to leave this page after transfer.

4.11.5. Probe Deployment Position Setup

Probe deployment position setup using the Meter is intended for use on-site at the actual point of deployment.

Deployment position setup is achieved by sending the Logger the current live GPS position and altitude directly from the Meter. Obviously, in order to achieve this, the Meter must have a current 3D fix. See section 4.8 for further details of GPS reception.

To setup the deployment position, press the **MENU** key to get to the Main Menu, then choose **Probe Deployment** followed by **Set ID & Position.**

The Set ID & Position screen will be displayed.

```
 Set ID & Position
 [Use arrow keys]
→ ID:Borehole 1
  View/Sync Position
```

Move the pointer down to 'View/Sync Position' and press the right arrow key or [OK]. The Probe's position screen will be displayed.

```
   Lat:N51 °22.8439'
  Long:E001°24.6435'
   Alt:+00050M
 [OK] = Sync to GPS
```

To transfer the current GPS position and altitude to the Probe, press the [OK] key.

After successful transfer of the current position, the 'ACTION SUCCESSFUL' message will be displayed. Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], the position will not be transferred to the Logger.

4.11.6. Logging Start and Duration Setup

The LeveLine® Loggers can then be set up to start logging data automatically at a pre-determined time for a set duration, or they can be set up for manual deployment.

To setup the logging start time and duration, press the **MENU** key to get to the Main Menu, then choose **Probe Deployment** followed by **Start & Duration.** The Set Start and Duration screen will be displayed.

```
Set Start & Duration
 →  Time:00:00:00
    Date:==/===/==
 Duration:00024 Hrs
```

4.11.6.1. Scheduled Deployment

To schedule a time and date for the Probe to start logging data, adjust the time and date fields on this screen using the up/down and left/right arrow keys. This time obviously needs to be in the future. If you input a time and date that has already passed, the Probe will start logging data immediately.

If you want to log data for a specific period of time after the start, set the logging duration (in whole hours). If you want the Probe to log data indefinitely, set the Duration field to 00000.

Once the start time, date and optional duration have been set up, transfer the settings to the Logger by pressing the OK key.

After successful setup, the 'ACTION SUCCESSFUL' message will be displayed. Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], your revised settings will not be transferred to the Logger.

4.11.6.2. Manual Deployment

If you are not certain of the exact time and date you want to start logging, the Logger can be set up for manual deployment. This involves setting up the logging interval and optional logging duration, then forcing the logger to start logging at the exact time of deployment using a PC running LeveLink™ software, a LeveLine® Meter or a QuickDeploy™ Key.

To setup the Probe for manual deployment, set the Time field to 00:00:00 and the Date field to ==/===/==. Finally, select the number of hours you want to log data for.

If you want to log data for a specific period of time after logging is manually started, set the logging duration (in whole hours). If you want the Probe to log data indefinitely, set the Duration field to 00000.

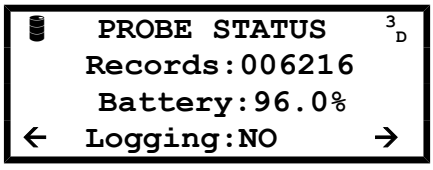
Once the start time, date and optional duration have been set up, transfer the settings to the Logger by pressing the OK key.

After successful setup, the 'ACTION SUCCESSFUL' message will be displayed. Use the [ESC] key to leave this page after transfer. If you press the [ESC] key before pressing [OK], your revised settings will not be transferred to the Logger.

Remember to subsequently start the LeveLine® logging when you deploy it! See sections 3.4 , 2.8.8 and 4.11.7 for further details of on-site deployment.

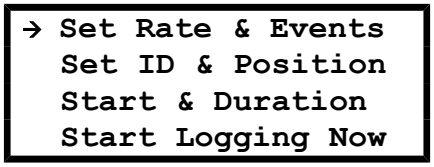
4.11.7. Manual Logging Start and Stop using the Meter

On the Probe Status screen, the bottom line indicated whether the Probe is currently logging data or not.



4.11.7.1. Start Logging Manually

To manually start the Probe logging, press the **MENU** key to get to the Main Menu, then choose **Probe Deployment.** The Probe Deployment screen will be shown.



The bottom line of this screen will read 'Start Logging Now'. Using the up/down arrow keys, move the pointer to the bottom line then press the right arrow key or the [OK] key.

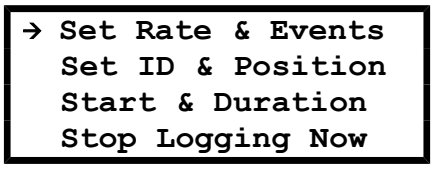
You will be asked to confirm that you have setup logging rate and duration. To start the Probe logging, press the [OK] key. To return to the Probe Deployment screen without starting the Probe logging, press the [ESC] key.

After logging has been successfully started, the 'ACTION SUCCESSFUL' message will be displayed. If the [ESC] key was pressed, the 'ACTION FAILED' message will be displayed to indicate that logging has not started.

4.11.7.2. Stop Logging Manually

If the Probe is logging data, the bottom line on the Probe Status screen will read: 'Logging:YES'.

To stop the Probe logging data, press the **MENU** key to get to the Main Menu, then choose **Probe Deployment.** The Probe Deployment screen will be shown.



The bottom line of this screen will read 'Stop Logging Now'. Using the up/down arrow keys, move the pointer to the bottom line then press the right arrow key or the [OK] key.

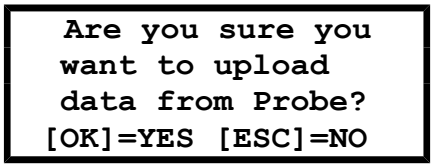
After logging has been successfully stopped, the 'ACTION SUCCESSFUL' message will be displayed.

4.12. Uploading Logged Data from the Probe

The LeveLine® Meter can be used to retrieve logged data from LeveLine® Probes in the field for later transfer to a PC running LeveLink™ software. The Meter is capable of storing up to 1.5 million data records from up to 300 separate Probes.

The number of records stored on the Probe is displayed on the second line of the Probe Status screen.

Uploading data from the Probe is extremely simple. Ensure you have a Probe connected then hit the [M+] key. A Probe Upload confirmation screen will be displayed.



To start the upload, hit the [OK] key. The screen will then display a progress counter until the upload is complete.

Once all the data points stored in the Probe have been uploaded, the 'ACTION SUCCESSFUL' message will be displayed.

If you press the [ESC] key during upload, the 'ACTION FAILED' message will be displayed and the data file in the Meter will be truncated.

Eventually, the Meter's memory will become full. In this event, a 'Not enough memory available in Meter' message will be displayed.

If the Probe you are attempting to upload data from has no logged points, a message showing 'the Probe's log memory is empty' will be displayed.

4.13. Downloading Logged Data from the Meter to a PC

To connect a LeveLine® Meter to you PC, a PC kit (Part No. LL-PC-KIT) described in section 1.2 should be used in conjunction with a LeveLine® Meter to USB adaptor (Part No. LLM-USB-AD) shown below.

Ensure the Meter is switched off. Connect the LeveLine® Meter to USB adaptor to the Meter as shown above, then connect to your PC using the LeveLine® PC Kit. Switch the Meter on.

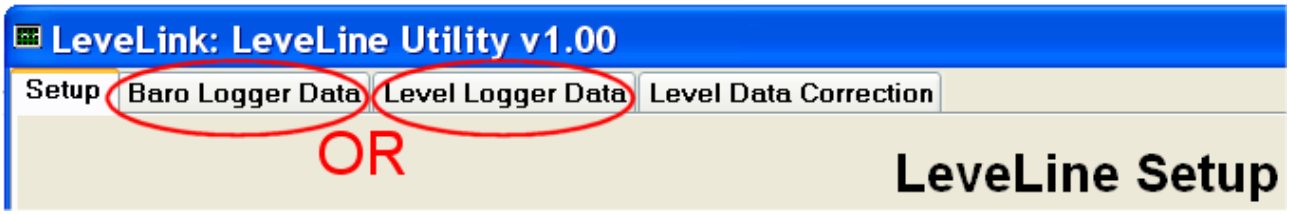
Prepare for data transfer by pressing the [MR] (Memory Recall) key. The Data Set Select screen will be shown.

```
  Select data set
 for download to PC
⇳ID:Borehole 1
045273 Level records
```

The third line of the screen shows the ID for the first data set held in the Meter's memory. The fourth line shows the number of records in the data set and the data type (either Level of Baro).

An up/down arrow symbol will be flashing next to the 'ID:' label to indicate you should use the up/down arrow keys to select a data set from the Meter's memory for download to the PC.

Once the title of the desired data set is displayed on the Meter's screen, you are ready to proceed. Identify the data type (Baro or Level) from the fourth line of the Meter's screen, then choose the corresponding upload tab on your PC.



If your data was air pressure data logged with a Baro Logger, click on the 'Baro Logger Data' tab. If your data was water level data logged with a Level Logger, click on the 'Level Logger Data' tab.

Now proceed to section 2.10 of this manual for details of data handling in LeveLink™.

During download of data to a PC, the Meter's keypad will be disabled and the up/down arrow symbol on line three will disappear. Data transfer can only be aborted by clicking on the Abort button within the Level Link software.

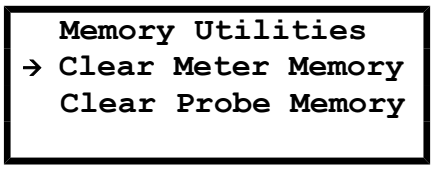
Once data download is complete, the keypad and flashing arrow symbol will be re-activated and further data can be selected for download to the PC.

To leave this screen, press the [ESC] key.

4.14. Memory Utilities

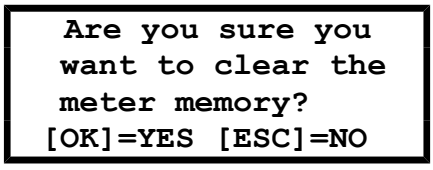
Using the Meter you can clear the memory in either the Probe or the Meter. To access the Memory Utilities, press the **MENU** key to get to the Main Menu, then choose **Memory Utilities.**

The Memory Utilities screen will be displayed.



4.14.1.1. Clearing the Meter Memory

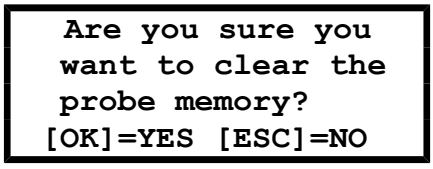
To clear the Meter's memory, select 'Clear Meter Memory'. A confirmation screen will be displayed.



Press [OK] to confirm or [ESC] to escape without clearing the memory.

4.14.1.2. Clearing the Probe Memory

To clear the Probe's memory, select 'Clear Probe Memory'. A confirmation screen will be displayed.



Press [OK] to confirm or [ESC] to escape without clearing the memory.

5. Cleaning and Maintenance

The LeveLine® Probes should always be cleaned after every use.

Ensure the connector cap is securely fitted to protect the socket, then rinse the unit thoroughly in fresh water.

5.1. Cleaning the Pressure Sensor

Remove the black end cap to reveal the pressure sensor hole. Rinse thoroughly and ensure all the holes in the cap are clear. Check that the pressure sensor hole in the end of the Probe is also clear.

If the pressure sensor hole appears to be blocked, carefully clear it with a soft tool such as a wooden or plastic toothpick. **Do not insert any sharp metal tools into the pressure sensor inlet.**

5.2. Cleaning the EC Cell (-CTD version only)

On a regular basis, thoroughly clean the inside of the nose sleeve and the four metal EC contacts situated in the EC cell with a soft cloth or toothbrush and non-abrasive detergent. Never use solvent or alcohol based products to clean the EC cell. After cleaning, replace the nose sleeve and re-calibrate the EC.

6. Connecting to Third Party Telemetry and Logging Devices

6.1. Introduction

The LeveLine® range of probes are designed to output live pressure and temperature data to a third party logging device using industry standard interfaces. The -CTD version also outputs live electrical conductivity and salinity data.

In order to translate the live pressure data into water level above the sensor, it is necessary to perform further calculations. These calculations are automatically carried out in the Aquaread® LeveLine® Meter and LeveLink™ PC Software, but if the LeveLine® probe is connected to a third party logging or telemetry device, level (depth) must be calculated by that device.

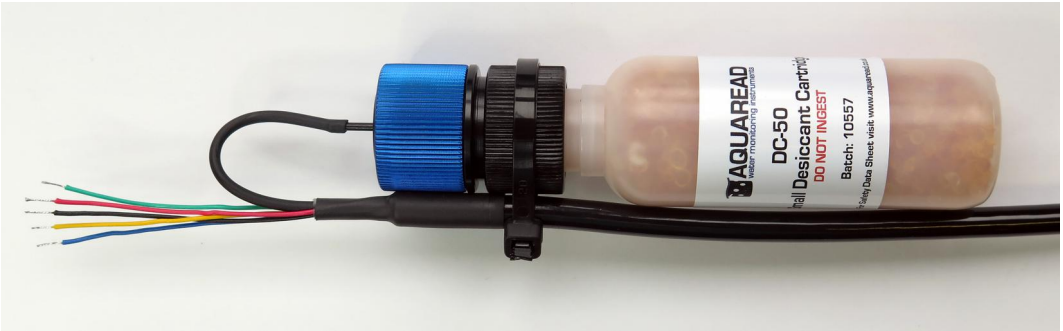
See section 6.17. Depth Calculation for Third Party Devices for further details.

6.2. Connections

The LeveLine® accessory cable LL-EXT-TEL-AD (extension cable to flying lead adaptor for telemetry) allows any LeveLine® Probe to be connected, via a standard LeveLine® extension cable (EXT-LL-XM), to a third party controller device.

This accessory terminates with a screened multicore cable, which allows external power to be supplied to the LeveLine® and facilitates bi-directional serial data communication. The basic model LeveLine® Mini Probe has a multicore cable permanently attached.

When installing a gauge (vented) type LeveLine® probe with a vented cable, it is essential to fit a desiccant housing and cartridge to the open end of the cable in order to prevent any moisture entering the cable or probe. See section 3.2.6.Fitting a Desiccant Housing and Cartridge



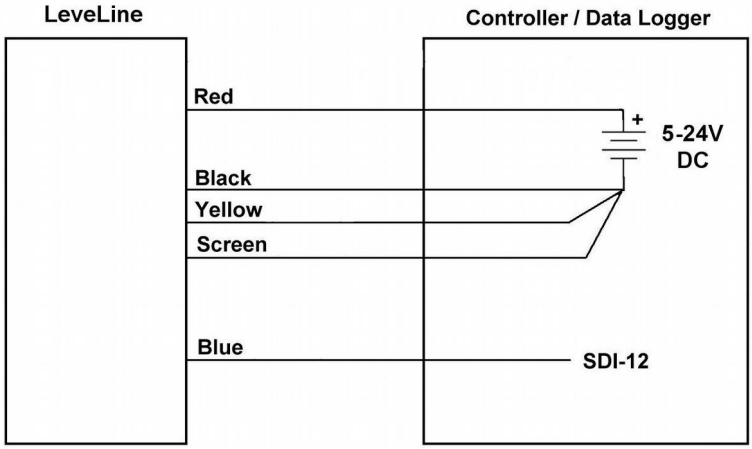
6.3. SDI-12 Digital Interface Wiring

In this configuration, the LeveLine® is usually in power saving (sleep) mode, during which time the LeveLine® Logger will draw around 1mA from the external supply. The LeveLine® Mini versions will draw around 2mA when in sleep mode.

Requests for data on the SDI-12 bus will wake the LeveLine® up and there will be a delay of up to 1 second before data is ready. The current drawn from the external supply by the standard LeveLine® Logger/Mini when awake is less than 10mA. The -CTD versions draw less than 20mA when awake.

As soon as data is ready to be sent, the LeveLine® will issue a 'service request' to the controller. Once the controller has read the data, the LeveLine® will automatically re-enter sleep mode.

Digital SDI-12 Operation



All cores not shown must be cut back and isolated

Six Core Cable Usage

Core Colour	Designation	Connection
Red	Power supply +ve	5V – 24V DC +ve power supply input
Black	Power supply –ve	Power supply ground
Blue	SDI-12	Controller SDI-12 I/O line
Green	RS485 +	Must be isolated and left floating
Yellow	SDI-12 / Modbus Select	Power supply -ve (see note below)
White	N/A	Not used. Cut back
Screen	Screen / Shield	Power supply or chassis ground

Note: The yellow core is used to select between SDI-12 or Modbus (RS485) serial data communications. **The yellow core must tied to the -ve power supply for SDI-12 mode.**

6.4. SDI-12 Data Communication Protocol

SDI-12 is a standard for interfacing data recorders with microprocessor-based sensors.

SDI-12 stands for serial/digital interface at 1200 baud. The following sections describe the protocol for communications between the LeveLine® Probes and SDI-12 data recorders complying with Version 1.3 of the SDI-12 standard.

6.5. SDI-12 Data Packet Formats

The LeveLine® responds to commands sent to it by an SDI-12 data recorder. Command packets should have the format:

<a><command-data>!

where:

- <a> is the LeveLine's device address (valid values are ASCII “0”-“9”, “A”-“Z”, and “a”-“z”) or the wild card address character “?”.
- <command-data> is a string of zero or more command dependent data characters (values in the range 0x20-0x7E, excluding 0x21 (ASCII “!”)).
- the packet is terminated by 0x21 (ASCII “!”).

Each command sent to the LeveLine® must be preceded by a break frame (12mS high) to wake the LeveLine® up.

Response packets have the format:

<a><response-data>[<crc>]<CR><LF>

where:

- <a> is the LeveLine's device address character.
- <response-data> is a string of zero or more command dependent data characters (values in the range 0x20-0x7E).
- <crc>, when present, is a string of 3 characters encoding the cyclic redundancy check of the response data (1st character in the range 0x40-0x4F, 2nd & 3rd characters in the range 0x40-0x7F).
- the packet is terminated by a carriage return followed by a line feed.

The formats of the individual command/response packets that the LeveLine® supports are described in the following subsections.

6.5.1. Acknowledge Active

This command allows the data recorder to check that the LeveLine® is present on the SDI-12 bus.

Command	Response
<a>!	<a><CR><LF>

6.5.2. Address Query

This command allows the data recorder to obtain a sensor's device address. It must only be issued when there is just one sensor attached to the bus, otherwise all sensors will respond, causing bus contention.

Command	Response
?!	<a><CR><LF>

6.5.3. Change Address

This command allows the data recorder to assign a new device address to the LeveLine®.

Command	Response
<a>A<b>!	<b><CR><LF>

- <b> is the new device address to be assigned to the unit (1 character, value “0”-“9”, “A”-“Z” or “a”-“z”).

6.5.4. Send Identification

This command allows the data recorder to retrieve some basic information about the LeveLine®.

Command	Response
<a>I!	<a><sdi-ver><vendor-id><model-id><firmware-ver><serial-nr><CR><LF>

- <sdi-ver> is the version of the supported SDI-12 standard (“13” for version 1.3).
- <vendor-id> is an 8-character vendor identification string (“AQUAREAD”).
- <model-id> is a 6-character device identification string (see note below).
- <firmware-ver> is a 3-digit LeveLine® firmware version string (e.g. “100” for v1.00).
- <serial-nr> is the LeveLine's serial number string (8 characters).

Model Identification Strings

- For the standard LeveLine® Probe the <model id> is (“LVLINE”).
- For the LeveLine - CTD® Probe the <model id> is (“LL-CTD”).
- For the standard LeveLine® Mini Probe the <model id> is (“LLMINI”).
- For the LeveLine® Mini - CTD Probe the <model id> is (“LLMCTD”).

6.5.5. Start Measurement

This command tells the LeveLine® to start making a measurement.

Command	Response
<a>M!	<a><time><nr-values><CR><LF>

- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “001” in this field.
- <nr-values> is a single digit specifying the number of measurements that will be returned by subsequent Send Data commands. The LeveLine® always places a value of “2” in this field.

6.5.6. Additional Measurements

The LeveLine® will respond to Additional Measurements commands, but will not make any measurements.

Command	Response
<a>M<set>!	<a><time><nr-values><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of additional measurements is being requested.
- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “000” in this field.
- <nr-values> is a single digit (“0”-“9”) specifying the number of measurements that will be returned by subsequent Send Data commands. The LeveLine® always places a value of “0” in this field.

6.5.7. Start Measurement and Request CRC

This command tells the LeveLine® to start making a measurement.

Command	Response
<a>MC!	<a><time><nr-values><CR><LF>

- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “001” in this field.
- <nr-values> is a single digit (“0”-“9”) specifying the number of measurements that will be returned by subsequent Send Data commands. The LeveLine® always places a value of “2” in this field.

6.5.8. Additional Measurements and Request CRC

The LeveLine® will respond to Additional Measurements with CRC commands, but will not make any measurements.

Command	Response
<a>MC<set>!	<a><time><nr-values><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of additional measurements is being requested.
- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “000” in this field.
- <nr-values> is a single digit (“0”-“9”) specifying the number of measurements that will be returned by subsequent Send Data commands. The LeveLine® always places a value of “0” in this field.

6.5.9. Start Concurrent Measurement

This command tells the LeveLine® to start making a measurement.

Command	Response
<a>C!	<a><time><nr-values><CR><LF>

- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “001” in this field.
- <nr-values> is a two-digit number (“01”-“20”) specifying the number of measurements that will be returned by a subsequent D0 command. The LeveLine® always places a value of “02” in this field.

6.5.10. Additional Concurrent Measurements

The LeveLine® will respond to Additional Concurrent Measurements commands, but will not make any measurements.

Command	Response
<a>C<set>!	<a><time><nr-values><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of additional measurements is being requested.
- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “000” in this field.
- <nr-values> is a two-digit number (“00”-“20”) specifying the number of measurements that will be returned by subsequent D commands. The LeveLine® always places a value of “00” in this field.

6.5.11. Start Concurrent Measurement and Request CRC

This command tells the LeveLine® to start making a measurement.

Command	Response
<a>CC!	<a><time><nr-values><CR><LF>

- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “001” in this field.
- <nr-values> is a two-digit number (“01”-“20”) specifying the number of measurements that will be returned by a subsequent D0 command. The LeveLine® always places a value of “02” in this field.

6.5.12. Additional Concurrent Measurements and Request CRC

The LeveLine® will respond to Additional Concurrent Measurements with CRC commands, but will not make any measurements.

Command	Response
<a>CC<set>!	<a><time><nr-values><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of additional measurements is being requested.
- <time> is the time in seconds (three digits) until the measurement will be ready. The LeveLine® always places a value of “000” in this field.
- <nr-values> is a two-digit number (“00”-“20”) specifying the number of measurements that will be returned by subsequent D commands. The LeveLine® always places a value of “00” in this field.

6.5.13. Start Verification

The LeveLine® will respond to Start Verification commands, but will not perform any self tests.

Command	Response
<a>V!	<a><time><nr-values><CR><LF>

- <time> is the time in seconds (three digits) until the self-test result will be ready. The LeveLine® always places a value of “000” in this field.

- <nr-values> is a single digit (“0”-“9”) specifying the number of numerical values that will be returned by subsequent D commands. The LeveLine® always places a value of “0” in this field.

6.5.14. Service Request

The service request is a signal sent by the LeveLine® to indicate that a measurement has been completed and is ready to read.

Service Request	<a><CR><LF>

6.5.15. Send Data

This command is used by the data recorder to retrieve the measurement values after a measurement has been completed.

Command	Response
<a>D<sequence-nr>!	<a><values>[<crc>]<CR><LF>

- <sequence-nr> is a single digit (“0”-“9”) indicating the data packet number being requested.
- <values> is a string of measurement results, each consisting of a sign character (“+” or “-”), 1-7 digits and an optional decimal point. The LeveLine® returns the temperature and pressure in the <values> field after a Start Measurement or Start Concurrent Measurement (with or without CRC request) if <sequence-nr> is “0”; in all other cases, the <values> field will be empty.
- the <crc> field will be present if measurement with CRC was requested, and is a 3 byte string containing the encoded CRC of the response packet.

The maximum size of the <values> field is 75 characters when following a concurrent measurement request, or 35 characters when following a non-concurrent measurement request.

6.5.16. Continuous Measurements

The LeveLine® will respond to Continuous Measurements commands, but will not return any measurements.

Command	Response
<a>R<set>!	<a><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of measurements is being requested.

6.5.17. Continuous Measurements and Request CRC

The LeveLine® will respond to Continuous Measurements with CRC commands, but will not return any measurements.

Command	Response
<a>RC<set>!	<a><crc><CR><LF>

- <set> is a digit (“1”-“9”) indicating which set of measurements is being requested.
- <crc> is a 3 byte string containing the encoded CRC of the response packet.

6.6. SDI-12 Device Address

The LeveLine® is assigned an SDI-12 device address, which is a single character from the set “0”-“9”, “A”-“Z” & “a”-“z”. A LeveLine® will only respond to commands beginning with its assigned device address or with the wild card address “?”.

The LeveLine's device address has a factory default value of “0”, and can be set to a different value by a Change Address command.

6.7. SDI-12 Unit Identification

In its response to a Send Identification command, the LeveLine® will report compatibility with SDI-12 version 1.3, the vendor ID “AQUAREAD”, the device model ID “LVLINE”, and the LeveLine's firmware revision number and serial number.

6.8. SDI-12 Measurement Commands

On reception of any Start Measurement, Additional Measurement, Start Concurrent Measurement or Additional Concurrent Measurement command (with or without CRC request), the LeveLine® will respond indicating a maximum time for the measurements to be ready and the number of measurements that will be returned in response to subsequent Send Data commands.

In response to the Start Measurement and Start Concurrent Measurement commands the measurement time will be 1 second and the number of measurements will be 2. In response to the Start Measurement and Start Concurrent Measurement commands the measurement time will be 0 seconds and the number of measurements will be 0.

After receiving the response to a Start Measurement command, the data recorder should wait for the LeveLine® to send a Service Request before requesting the measurements with a Send Data command.

After a Start Measurement command & response, the data recorder may abort the measurement by sending a command to another device (preceded by a break frame) or by sending a command other than Send Data to the LeveLine®.

After receiving the response to a Start Concurrent Measurement command, the data recorder should wait for the measurement time to elapse before requesting the measurements with a Send Data command.

After a Start Concurrent Measurement command & response, the data recorder may abort the measurement by sending a command other than Send Data to the LeveLine®. (The data recorder may send commands to other devices on the SDI-12 bus without aborting a concurrent measurement.)

If the data recorder sends any Send Data command to the LeveLine® not preceded by any form of measurement start command or after aborting a measurement sequence, then the response will not contain any data values.

Sequence initiated with Start Measurement command (Standard Probe):

Command	Response
<a>M! or <a>MC!	<a>0012<CR><LF>
<a>D0!	<a><temperature><pressure><CR><LF> or <a><temperature><pressure><crc><CR><LF>

Sequence initiated with Start Concurrent Measurement command (Standard Probe):

Command	Response
<a>C! or <a>CC!	<a>00102<CR><LF>
<a>D0!	<a><temperature><pressure><CR><LF> or <a><temperature><pressure><crc><CR><LF>

Sequence initiated with Start Measurement command (-CTD Probe):

Command	Response
<a>M! or <a>MC!	<a>0016<CR><LF>
<a>D0!	<a><temperature><pressure><ABS-EC><EC-20><CR><LF> or <a><temperature><pressure><ABS-EC><EC-20><crc><CR><LF>
<a>D1!	<a><EC-25><SAL><CR><LF> or <a><EC-25><SAL><crc><CR><LF>

Sequence initiated with Start Concurrent Measurement command (-CTD Probe):

Command	Response
<a>C! or <a>CC!	<a>00106<CR><LF>
<a>D0!	<a><temperature><pressure><ABS-EC><EC-20><EC-25><SAL> <CR><LF> or <a><temperature><pressure><ABS-EC><EC-20><EC-25><SAL> <crc><CR><LF>

Where:

- ABS-EC is the absolute (uncorrected) EC value in µS/cm.
- EC-20 is EC in µS/cm corrected to 20°C.
- EC-25 is EC in µS/cm corrected to 25°C.
- SAL is salinity in PSU, which is an equivalent to ppt.

In the event of an error or over range condition, EC or SAL values will be sent as negative.

6.9. SDI-12 Cyclic Redundancy Check

The cyclic redundancy check included in responses to the Send Data command is calculated on the contents of the response, starting with the sensor address character and ending with the last response character before the start of the CRC field.

The CRC field is composed of three characters in the range 0x40-0x7F, which encode the 16-bit CRC value as follows:

1st character: binary $0100C_{15}C_{14}C_{13}C_{12}$
2nd character: binary $01C_{11}C_{10}C_9C_8C_7C_6$
3rd character: binary $01C_5C_4C_3C_2C_1C_0$

where C_n is the *n*th bit of the CRC.

The algorithm for calculating the CRC is as follows:

```
Set crc = 0
For each message character c:
   Set crc = crc XOR c
   Repeat 8 times:
      If least significant bit of crc is 1,
            Shift crc right by one bit
            Set crc = crc XOR 0xA001
      Otherwise,
            Shift crc right by one bit
```

6.10. MODBUS Communication Protocol

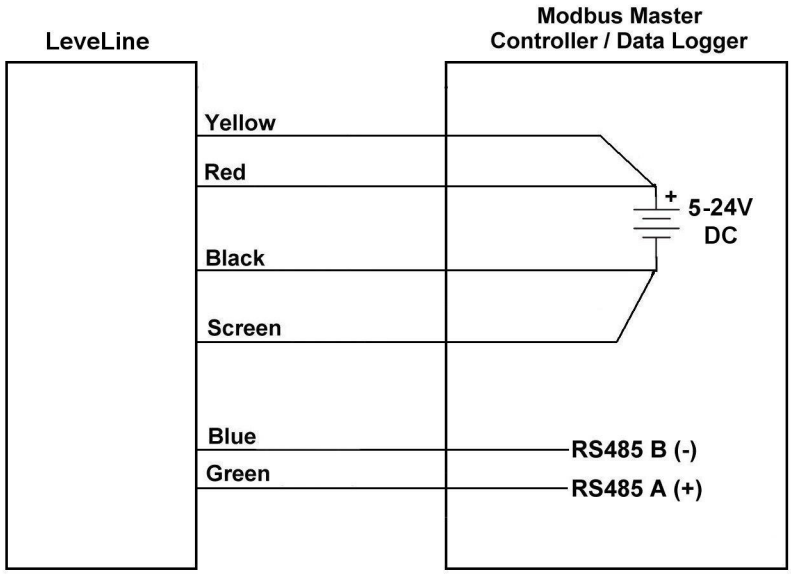
The LeveLine® supports the slave device side of the Modbus communication standard in RTU and ASCII modes, and responds appropriately to commands sent to it by a Modbus master device.

6.11. MODBUS Digital Interface Wiring

In the LeveLine®, Modbus is implemented over a half-duplex 3.5V RS-485 serial interface.

In this configuration, the LeveLine® is permanently on and Modbus data is instantly available on request. The current drawn from the external supply by the standard LeveLine® Logger/Mini in this mode is less than 10mA. The -CTD versions draw less than 20mA.

Digital Modbus Operation



All cores not shown must be cut back and isolated

Six Core Cable Usage

Core Colour	Designation	Connection
Red	Power supply +ve	5V – 24V DC +ve power supply input
Black	Power supply –ve	Power supply ground
Blue	RS485 (-/B)	Controller RS485 (- or B) line
Green	RS485 (+/A)	Controller RS485 (+ or A) line
Yellow	SDI-12 / Modbus Select	Power supply +ve (see note below)
White	N/A	Not used. Cut back
Screen	Screen / Shield	Power supply or chassis ground

Note: The yellow core is used to select between SDI-12 or Modbus (RS485) serial data communications. **The yellow core must be tied to the +ve power supply for Modbus mode.**

6.12. MODBUS Data Frame Format

Each data frame transferred via the RS-485 interface represents one byte of data. A data frame has the following format:

1. 1 start bit (space/0)
2. 8 (RTU mode) or 7 (ASCII mode) data bits (least significant bit first)
3. 1 parity bit (default: even)
4. 1 stop bit (mark/1)

6.13. MODBUS Communication Sequence

All Modbus communication transactions are initiated by the master. The master initiates a transaction by transmitting a command packet. Commands fall into two categories: broadcast and unicast.

Unicast commands are used for addressing slave devices individually. An addressed slave device processes the command and sends an appropriate response packet back to the master.

Broadcast commands are used for addressing all slave devices at once. All slaves devices process broadcast commands, but do not send anything back to the master in response (because this would cause bus contention).

6.14. MODBUS Data Packet Format

All Modbus data packets have the format:

Field	Size	Content
<a>	1 byte	Slave address (valid values 0x01-0xF7 when a single slave is addressed, 0x00 for commands broadcast to all slaves)
<function-code>	1 byte	Function code that identifies the function of the data packet (valid values 0x01-0x7F for commands & successful responses, 0x81-0xFF for exception responses)
<data>	0-252 bytes	Function dependent data
<crc>	2 bytes	16-bit cyclic redundancy check

In broadcast commands sent by the master, the address byte will contain 0. In unicast commands, the address byte will contain the address of the slave device to which the command is being sent.

In responses from slaves, the address byte will contain the address of the slave which generated the response.

If the LeveLine® successfully handles a command, its response will contain the same function code as the command. If it cannot successfully handle a command, the LeveLine® will generate an exception response with the function code set to 0x80 + the command's function code.

In the <data> field, numerical values of size greater than 8 bits are transmitted most significant byte first. In the <crc> field, the CRC is transmitted least significant byte first.
The maximum packet size is 256 bytes.

Table 3 summarises the Modbus functions supported by the LeveLine® and the following subsections describe their command & response packet formats.

Function	Function Code
Read Holding Registers	0x03
Read Input Registers	0x04
Write Holding Register	0x06
Write Holding Registers	0x10
Report Slave ID	0x11

Table 3: Supported Modbus Functions

6.14.1. Exception Responses

If a command is unsupported or has invalid parameters, the LeveLine® will return an exception response with the format:

Field	Size	Content
<a>	1 byte	Slave address
<exception-function-code>	1 byte	Function code of the command + 0x80
<exception-code>	1 byte	The type of exception 1 – Unsupported command function code 2 – Invalid data address in command 3 – Invalid data value in command
<crc>	2 bytes	CRC

6.14.2. Read Holding Registers

This command reads one or more Modbus holding registers, and has the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x03
<start-address>	2 bytes	Base address of the block of registers to be read (0x0000-0xFFFF)
<nr-registers>	2 bytes	The number of registers to be read (0x0001-0x007D)
<crc>	2 bytes	CRC

NOTE: The address in the <start-address> field is the register number – 1.

The LeveLine® will send a response with the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x03
<values-size>	1 byte	Size in bytes of <values> field (equal to 2 x <nr-registers>)
<values>	<values-size> bytes	Block of data containing the values of the requested registers, 2 bytes per register, registers in order of increasing address from <start-address> onwards
<crc>	2 bytes	CRC

6.14.3. Read Input Registers

This command reads one or more Modbus input registers and has the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x04
<start-address>	2 bytes	Base address of the block of registers to be read (0x0000-0xFFFF)
<nr-registers>	2 bytes	The number of registers to be read (0x0001-0x007D)
<crc>	2 bytes	CRC

NOTE: The address in the <start-address> field is the register number – 1.

The LeveLine® will send a response with the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x04
<values-size>	1 byte	Size in bytes of <values> field (equal to 2 x <nr-registers>)
<values>	<values-size> bytes	Block of data containing the values of the requested registers, 2 bytes per register, in order of increasing address from <start-address> onwards
<crc>	2 bytes	CRC

6.14.4. Write Holding Register

This command writes a value to a single Modbus holding register and has the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x06
<address>	2 bytes	Address of the register to be written (0x0000-0xFFFF)
<value>	2 bytes	Value to be written to the register (0x0000-0xFFFF)
<crc>	2 bytes	CRC

NOTE: The address in the <start-address> field is the register number – 1.

The LeveLine® will set the register to the specified value and echo the received command packet as its response.

6.14.5. Write Holding Registers

This command writes a set of values to a contiguous block of Modbus holding registers and has the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x10
<start-address>	2 bytes	Base address of the block of registers to be written (0x0000-0xFFFF)
<nr-registers>	2 bytes	The number of registers to be written (0x0001-0x007B)
<values-size>	1 byte	Size in bytes of <values> field (equal to 2 x <nr-registers>)
<values>	<values-size> bytes	Block of data containing the values to be written to the registers, 2 bytes per register, in order of increasing address from <start-address> onwards
<crc>	2 bytes	CRC

NOTE: The address in the <start-address> field is the register number – 1.

The LeveLine® will set the registers to the specified values and send a response with the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x10
<start-address>	2 bytes	Base address of the block of registers (0x0000-0xFFFF)
<nr-registers>	2 bytes	The number of registers (0x0001-0x007B)
<crc>	2 bytes	CRC

6.14.6. Report Slave ID

This command allows the master to retrieve identification information from the slave, and has the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x11
<crc>	2 bytes	CRC

On reception of this command, the LeveLine® will return a response with the format:

Field	Size	Content
<a>	1 byte	Slave address
<function-code>	1 byte	0x11
<data-size>	1 byte	The size of the rest of the packet, from <slave-id> to <data> inclusive (15 for format v1)
<slave-id>	1 byte	0x01
<run-status-indicator>	1 byte	0xFF
<format-ver>	1 byte	Version number indicating the format of the

		rest of the packet (currently 0x01)
<data>	12 bytes (format version 1)	Block of data containing product information
<crc>	2 bytes	CRC

Format version 1 of the <data> block is:

<serial-nr>	8 bytes	The LeveLine's serial number (an ASCII string)
<fw-ver>	2 bytes	The LeveLine's firmware version number x 100
<pressure-sensor-type>	1 bytes	The pressure sensor type (0 = absolute, 1 = gauge)
<pressure-rating>	1 bytes	The pressure sensor rating (bar)

6.15. MODBUS Register Map

The Modbus specification defines 4 classes of addressable data: discrete inputs, coils, input registers & holding registers. The characteristics of these classes are shown in the table below.

	Read Only	**Read/Write**
Single bit	Discrete Inputs	Coils
16-bit	Input Registers	Holding Registers

Modbus Data Classes

The LeveLine® implements all of its registers as holding registers or input registers. The single bit classes are not used and the command functions for accessing them are not implemented.

The holding registers allowing configuration of the LeveLine® are summarised in the table below.

Register Number	**Register Address (used in Modbus commands)**	**Description**
1	0x0000	Slave address (1 – 247)
2	0x0001	Modbus mode (0 = RTU, 1 = ASCII)
3	0x0002	Serial communication speed (1200, 2400, 4800, 9600, 19200, 38400, 57600)
4	0x0003	Serial communication parity (0 = none, 2 = even, 3 = odd)

Modbus Holding Registers

The input registers provide a way to read the LeveLine's measurements and are summarised in the tables below.

Register Number	Register Address (used in Modbus commands)	Description: Standard LeveLine®
1	0x0000	Temperature (°C × 100)
2	0x0001	Barometric pressure (mbar × 10) – upper 16 bits
3	0x0002	Barometric pressure (mbar × 10) – lower 16 bits

Standard LeveLine® Modbus Input Registers

Register Number	Register Address (used in Modbus commands)	Description: LeveLine – CTD®
1	0x0000	Temperature (°C × 100)
2	0x0001	Pressure (mbar × 10) – upper 16 bits
3	0x0002	Pressure (mbar × 10) – lower 16 bits
4	0x0003	Electrical conductivity (µS/cm) – upper 16 bits
5	0x0004	Electrical conductivity (µS/cm) – lower 16 bits
6	0x0005	Electrical conductivity (corrected to 20°C) (µS/cm) – upper 16 bits
7	0x0006	Electrical conductivity (corrected to 20°C) (µS/cm) – lower 16 bits
8	0x0007	Electrical conductivity (corrected to 25°C) (µS/cm) – upper 16 bits
9	0x0008	Electrical conductivity (corrected to 25°C) (µS/cm) – lower 16 bits
10	0x0009	Salinity (PSU/ppt × 100)

LeveLine – CTD® Modbus Input Registers

All measurement values are two's complement numbers.

6.15.1. Slave Address

Holding register 1 contains the LeveLine's slave address, which is a value in the range 1-247. It's factory default value is 1. NOTE: If a command writes a new value to holding register 1, the slave address contained in the response to the command will be the original slave address, not the new one.

6.15.2. Modbus Mode

Holding register 2 can be set to select between Modbus RTU and ASCII modes of communication. Its factory default value is 0 (RTU mode). Note that if this register is set to a new value, the change in communication mode will occur after the response has been transmitted.

6.15.3. Serial Communication Speed

Holding register 3 can be set to select the communication baud rate. Its factory default value is 19200, and other valid values are 1200, 2400, 4800, 9600, 38400 and 57600. Note that if this register is set to a new value, the change in communication speed will occur after the response has been transmitted.

6.15.4. Serial Communication Parity

Holding register 4 can be set to select the communication parity type. Its factory default value is 2 (even parity). Note that if this register is set to a new value, the change in communication speed will occur after the response has been transmitted. Note also that when set to 0 (no parity), the parity bit in each transmitted byte frame is replaced with an extra stop bit.

6.15.5. Input Registers

The input registers hold the measurements read from the LeveLine®.

6.16. MODBUS Cyclic Redundancy Check

The cyclic redundancy check is calculated on the entire contents of the packet, starting with the slave address and ending with the last byte before the start of the CRC field.

The CRC field is composed of the two bytes of the CRC value, least significant byte first, most significant byte second. (Note that this is the opposite order to multi-byte values in the <data> field of the packet.)
The algorithm for calculating the CRC is as follows:

```
Set crc = 0xFFFF
For each message character c:
   Set crc = crc XOR c
   Repeat 8 times:
        If least significant bit of crc is 1,
                Shift crc right by one bit
                Set crc = crc XOR 0xA001
        Otherwise,
                Shift crc right by one bit
```

6.17. Depth Calculation for Third Party Devices

This section details the method by which sensor depth can be derived from the depth pressure output from any model of LeveLine® probe.

These calculations are automatically carried out in the Aquaread® LeveLine® Meter and LeveLink™ PC Software. If the LeveLine® probe is connected to a third party logging or telemetry device, depth must be calculated by that device or its controlling software.

Depth is calculated using the depth pressure being output from the LeveLine® probe, the local barometric pressure and water density, which is derived from water temperature and salinity.

Depth_Pressure is output by the LeveLine® probes in mB. Temp is output by the LeveLine® probes in degrees Centigrade. If the LeveLine® probe being used is an ABS type, local barometric pressure (in mB) must be taken into account.

If the LeveLine® probe being used is a GAUGE type, local barometric pressure should be ignored because it has already been automatically subtracted from the depth pressure in the probe.

SAL (salinity in PSU) is output by the LeveLine® -CTD model probes only. If you are not using a -CTD probe and do not have access to live salinity data, SAL values of around 0.4 PSU should be used for clean surface water and around 33.0 PSU for sea water.

6.17.1. Water Density Calculation

Constants:

Den_R0 = 3.9863
Den_R1 = 288.9414
Den_R2 = 68.12963
Den_R3 = 508.9292
Den_K00 = 0.824493
Den_K01 = -0.0040899
Den_K02 = 0.000076438
Den_K03 = -0.00000082467
Den_K04 = 0.0000000053675
Den_K10 = -0.005724
Den_K11 = 0.00010227
Den_K12 = -0.0000016546
Den_K20 = 0.00048314

Formulae for calculating water density. First calculate A0, A1 and A2:

A0 = Den_K00 + Den_K01 x Temp + Den_K02 x $Temp^2$ + Den_K03 x $Temp^3$ + Den_K04 x $Temp^4$
A1 = Den_K10 + Den_K11 x Temp + Den_K12 x $Temp^2$
A2 = 1000.0 - $(Temp - Den_R0)^2$ x (Temp + Den_R1) / (Temp + Den_R2) / Den_R3

Density = A2 + (A0 x SAL + A1 x $SAL^{1.5}$ + Den_K20 x SAL^2)

6.17.2. Depth Calculation

Formula for calculating depth in meters using an ABS type probe:

Depth (m) = (ABS_Depth_Pressure - Baro_Pressure) / (0.0981 * density)

Formula for calculating depth in meters using a GAUGE type probe:

Depth (m) = GAUGE_Depth_Pressure / (0.0981 * density)

7. Limited Warranty

All LeveLine® Meters and Probes are guaranteed for two years from date of purchase against defects in workmanship and materials when used for their intended purpose and maintained according to instructions.

This warranty is limited to repair or replacement free of charge. Accidental damage, misuse, tampering, lack of prescribed maintenance, water ingress through unprotected Meter and Probe sockets, and damage caused by leaking or flat batteries are not covered.

If service is required, contact our Service Department directly by email in the first instance (service@aquaread.com). Report the model, date of purchase, serial number and problem. You will be given a Returns Authorisation number by our Service Department. You should then return the equipment, thoroughly cleaned, properly packaged, carriage paid, to the address you are given. If the equipment is within warranty, any necessary repairs will be carried out and your equipment will be returned free of charge.

If the repair is not covered by the warranty, you will be given an estimate for the costs of repair and return carriage. Upon receipt of payment, your equipment will be repaired and returned.

Please note: The majority of perceived problems can be rectified by careful study of this instruction manual, use of the TROUBLESHOOTING section below, or with a little help from our engineers over the phone**. Always contact our Service Department prior to returning any equipment.**

7.1. Cleaning Prior To Return

In order to protect the health and safety of our employees, any equipment returned for service **must be thoroughly cleaned and decontaminated** prior to despatch, and must be accompanied by a completed copy of the Decontamination Certificate printed below.

Any equipment returned for service without a satisfactory Decontamination Certificate, or any equipment deemed by our engineers to be contaminated, will be quarantined or returned pending receipt of a properly completed Decontamination Certificate.

7.2. Decontamination Certificate

Please print this certificate, complete all sections, and enclose it with any returned equipment.

Decontamination Certificate

Company Name: _____

Address:

_____

_____

_____

_____

Postal code: _____

Country: _____

Phone: _____ email: _____

Product: _____ Serial No.: _____

Contaminant (if known): _____

Decontamination Procedure: _____

_____

Certified by (print name) : _____ Title: _____

Date: _____

Signature: _____

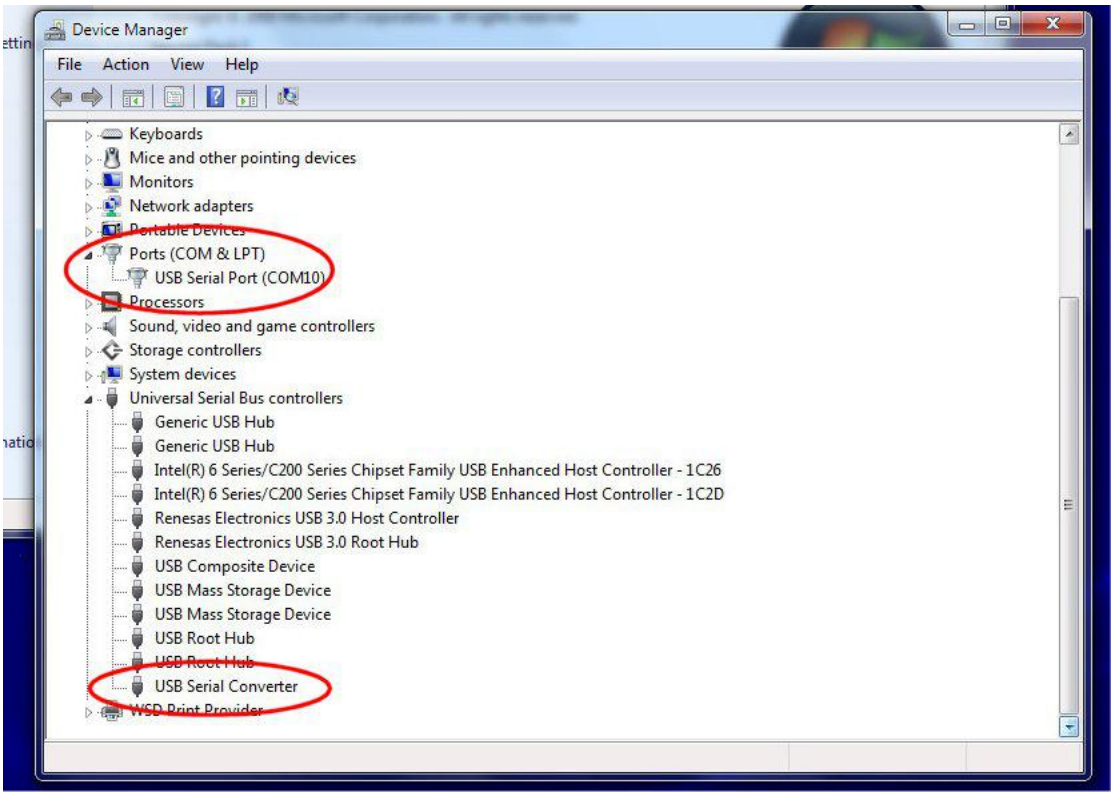
8. TROUBLESHOOTING

This section details some of the common difficulties you may encounter when using the LeveLine® Meter, Logger and LeveLink™ software. Try all the suggested remedies. If your problem is still unresolved, contact our Service Department (service@aquaread.com).

Problem	Cause / Remedy
LeveLine® Logger will not log any data or has stopped logging data unexpectedly.	✓ Probably not set up properly. Ensure the clock is correctly set and that you have programmed a start time and a logging rate. ✓ Connect to LeveLink™ or a Meter and check the battery and memory level. Logging stops automatically when the battery or memory gets low.
LeveLine® Logger memory fills up very quickly or battery goes flat quickly.	✓ Probably the result of a very fast logging or event checking rate. Always set the logging rate and event checking rate as slow as your application will allow in order to conserve memory and battery.
The LeveLine® Meter will not turn on when the on/off key is pressed.	✓ Batteries are probably dead or incorrectly fitted. Check you have fresh batteries fitted and that they are inserted the correct way round.
The LeveLine® Meter turns on but turns off again almost immediately.	✓ Batteries are probably nearly dead or incorrectly fitted. Check you have fresh batteries fitted and that they are inserted the correct way round.
The LeveLine® Meter can not find the Probe.	✓ Probably a poor connection. Switch the LeveLine® Meter off, disconnect the Probe, ensure there is no debris or moisture in the plugs and sockets, then re-connect ensuring they are fully inserted and that the screw collars are fully tightened.
The GPS in the LeveLine® Meter will not show a position fix.	✓ The LeveLine® Meter probably does not have a good enough view of the available satellites. Ensure there are no obstructions between the LeveLine® Meter and the open sky. Remember, GPS **does not** work indoors.
The LeveLink™ software can not find the LeveLine® Meter or Probe.	✓ The USB drivers may not be properly installed. Reinstall the USB drivers carefully following the instructions in section 2.4 and the advice in section 8.1 ✓ There may be a problem with the USB socket on the PC, try an alternative socket.
Battery electrolyte leakage detected in the Meter's battery compartment.	✓ Remove and discard the batteries immediately. Thoroughly clean the battery compartment and terminals. If the battery terminals are corroded, contact our Service Department for return instructions.

8.1. Troubleshooting LeveLink™

If the LeveLink™ software can not find the Probe, or if Windows® reports a problem installing the drivers, go to your Windows® Device Manager. The following two components should be present:



If one or other of these components are not installed or are showing an error, re-install the drivers forcing Windows® to search your temporary directory for the drivers you downloaded from the Aquaread® website.

If more than one USB Serial Port is showing, determine which one is associated with the LeveLine® cable (by unplugging it then re-connecting it), then temporarily disable all other USB serial ports as they may be causing interference with communications to the LeveLine® Probe.

9. DECLARATION OF CONFORMITY

Aquaread® Ltd declares that the equipment described herein is in compliance with the essential requirements and other relevant provisions of Directives 2004/108/EC and 1999/5/EC.

10. Technical Specification

General	LeveLine	LeveLine - Baro	LeveLine - Mini
Temperature ranges	Operational: -20 - 80° C (-4 - 176° F) Storage: -40-80° C (-40-176° F) **Non Freezing**	Operational: -20 - 80° C (-4 - 176° F) Storage: -40-80° C (-40-176° F) **Non Freezing**	Operational: -20 - 80° C (-4 - 176° F) Storage: -40-80° C (-40-176° F) **Non Freezing**
Diameter	22mm (0.785 in)	22mm (0.785 in)	22mm (0.785 in)
Length	186mm (7.32 in)	186mm (7.32 in)	127mm (5.0 in)
Weight	150g (0.33 lb)	150g (0.33 lb)	120g (0.26lb)
Materials	Titanium body, Delrin nose cone & hanger	Titanium body, Delrin nose cone & hanger	Titanium body, Delrin nose cone & hanger (socket versions)
Output options	Modbus/RS485, SDI-12, Aquaread proprietary	Modbus/RS485, SDI-12, Aquaread proprietary	Modbus/RS485, SDI-12, Aquaread proprietary
Battery type & typical life	3.6V lithium, up to 10 years dependent on log rate	3.6V lithium, up to 10 years dependent on log rate	N/A
External power	5 - 24 VDC	5 - 24 VDC	5 - 24 VDC
Memory Size	8.0 MB	2.0 MB	N/A
Data record storage	500,000	150,000	N/A
Log types	Linear, Event & User-Selectable Schedule with Future Start, Future Stop, Deploy Start and Real Time View	Linear, Event & User-Selectable Schedule with Future Start, Future Stop, Deploy Start and Real Time View	N/A
Fastest logging rate	10 per second	1 per minute	N/A
Fastest Modbus output rate	10 per second	10 per second	10 per second
Fastest SDI-12 output rate	1 per second	1 per second	1 per second
Real-time clock (note 2)	Accurate to ± 2 second/24-hr period (± 15 minutes/year)	Accurate to ± 2 second/24-hr period (± 15 minutes/year)	N/A
Pressure Sensor			
Type / Material	Piezoresistive: ceramic	Piezoresistive: ceramic	Piezoresistive: ceramic
Range (Absolute)	10M (33 ft) 20M (65 ft) 50M (164ft) 100M (3268ft)	0 to 16.7 psi (0 to 1.15 bar)	10M (33 ft) 20M (65 ft) 50M (164ft) 100M (3268ft)
Range (Gauge)	10M (33 ft) 20M (65 ft) 50M (164ft)	N/A	10M (33 ft) 20M (65 ft) 50M (164ft)
Maximum pressure	Max 2x range, Burst 2.5x range	Max 2x range, Burst 2.5x range	Max 2x range, Burst 2.5x range
Accuracy @ 25° C (note 1)	±0.05% FS	±0.1% FS	±0.05% FS
Accuracy (overall) (note 2)	±0.1% FS	±0.2% FS	±0.1% FS
Resolution	0.002% FS or 1mm whichever is greater	0.1mb	0.002% FS or 1mm whichever is greater
Temperature Sensor			
Accuracy	±0.1° C	±0.1° C	±0.1° C
Resolution	0.01° C	0.01° C	0.01° C
Warranty			
Standard	2 years	2 years	2 years

Notes:

1. **Across factory calibrated pressure range at constant temperature.**
2. **Across factory calibrated pressure and temperature range (5°C - 25°C). Accuracy will degrade outside these ranges.**
3. **Aquaread® Ltd reserves the right to change specifications without notice.**

General	LeveLine - CTD	LeveLine Mini - CTD
Temperature ranges	Operational: -20 - 80° C (-4 - 176° F) Storage: -40-80° C (-40-176° F) **Non Freezing**	Operational: -20 - 80° C (-4 - 176° F) Storage: -40-80° C (-40-176° F) **Non Freezing**
Diameter	22mm (0.785 in)	22mm (0.785 in)
Length	245mm (9.65 in)	177mm (6.97 in)
Weight	180g (0.40 lb)	155g (0.34lb)
Materials	Titanium body, Delrin nose cone & hanger	Titanium body, Delrin nose cone & hanger
Output options	Modbus/RS485, SDI-12, Aquaread proprietary	Modbus/RS485, SDI-12, Aquaread proprietary
Battery type & typical life	3.6V lithium, up to 10 years dependent on log rate	N/A
External power	5 - 24 VDC	5 - 24 VDC
Memory Size	8.0 MB	N/A
Data record storage	500,000	N/A
Log types	Linear, Event & User-Selectable Schedule with Future Start, Future Stop, Deploy Start and Real Time View	N/A
Fastest logging rate	1 per second	N/A
Fastest Modbus output rate	1 per second	1 per second
Fastest SDI-12 output rate	1 per second	1 per second
Real-time clock (note 2)	Accurate to ± 2 second/24-hr period (± 15 minutes/year)	N/A
Pressure Sensor		
Type / Material	Piezoresistive: ceramic	Piezoresistive: ceramic
Range (Absolute)	10M (33 ft) 20M (65 ft) 50M (164ft) 100M (3268ft)	10M (33 ft) 20M (65 ft) 50M (164ft) 100M (3268ft)
Range (Gauge)	10M (33 ft) 20M (65 ft) 50M (164ft)	10M (33 ft) 20M (65 ft) 50M (164ft)
Maximum pressure	Max 2x range, Burst 2.5x range	Max 2x range, Burst 2.5x range
Accuracy @ 25° C (note 1)	±0.05% FS	±0.05% FS
Accuracy (overall) (note 2)	±0.1% FS	±0.1% FS
Resolution	0.002% FS or better	0.002% FS or better
Electrical Conductivity		
Range	0 – 200,000µS/cm	0 – 200,000µS/cm
Resolution	1µS/cm	1µS/cm
Accuracy	+/-1% reading or +/- 1µS/cm whichever is greater See note 3	+/-1% reading or +/- 1µS/cm whichever is greater See note 4
Salinity (see note 4)		
Range	0 – 70PSU (ppt)	0 – 70PSU (ppt)
Resolution	0.01PSU (ppt)	0.01PSU (ppt)
Accuracy	+/-1% reading or +/- 0.1PSU whichever is greater See note 3	+/-1% reading or +/- 0.1PSU whichever is greater See note 3
Temperature Sensor		
Accuracy	±0.1° C	±0.1° C
Resolution	0.01° C	0.01° C
Warranty		
Standard	2 years	2 years

Notes:

1. **Across factory calibrated pressure range at constant temperature.**
2. **Across factory calibrated pressure and temperature range (5°C - 25°C). Accuracy will degrade outside these ranges.**
3. **At the calibration point at 25°C.**
4. **Reading calculated from EC and temperature values.**
5. **Aquaread® Ltd reserves the right to change specifications without notice.**