

WDP

Water Depth Probe with MicroLogger

Model 8007WDP



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1 INTRODUCTION

The UNIDATA Model 8007WDP, *also known as the 8007 Digital Water Level Recorder (DWLR)*, is a complete water level monitoring system. It is designed to be permanently submerged in water and to measure and record depth and water level. The can is designed to monitor underground, surface and marine water levels, and can also be used for any other application requiring long term, accurate and self-powered water level data collection.

It consists of a pressure sensor, data logger and power supply in a small housing with an attached cable. The WDP is available in 10m, 20m, 50m and 100m ranges. It will operate for up to five years from internal batteries. The instrument is particularly well suited to remote sites where data must be collected for long periods without regular attendance, external power or communications. However, it can use external power and telephone, satellite or radio communications if these are available and are required by the project.

Each instrument is supplied with all the accessories required to install and operate it at a field site. To achieve very high accuracy, each WDP is calibrated by an automated, computer controlled, calibration system. The derived calibration factors are saved within the instrument and are used to automatically adjust each measurement. The factors are also reported on the calibration certificate supplied.

The service life of the WDP is indefinite provided it is not subjected to mishandling. The instrument does not require recalibration unless it is disassembled or damaged. Like all pressure instruments, the sensor calibration may change if the sensor is buried or exposed to severe chemical or biological fouling. Cleaning the sensor will normally restore the original calibration. Regular site checks to detect and fix any such changes will improve the data quality.

This manual covers preparation, installation, operation and maintenance of the instrument. It also includes information on data management. Contact your nearest UNIDATA representative for further information or assistance.

1.1 Functional Overview

The WDP uses a pressure sensor to determine the water depth. The errors introduced by this method have been minimised by the instrument design. The water density can be set in the instrument software to suit your site. Compensation algorithms are used to reduce the effect of temperature on the sensor calibration. A vent tube inside the connection cable removes the effects of atmospheric pressure on the measured water pressure.

The pressure is used to calculate the distance between the sensor and the water surface. This is logged as depth. A datum adjustment value or offset can be added to this depth and this is presented as water level. The sensor temperature and the battery voltage can also be logged.

When installed in wells and bores, the WDP can be suspended by the special cable moulded to the instrument. This cable is Kevlar™ reinforced, has a polyurethane jacket and is supplied with an adjustable suspension link. For surface water monitoring, the instrument can be inserted into a vertical or sloping duct fixed to a structure or the stream bank.

The instrument can be programmed with your computer and the logged data can be retrieved, displayed and saved using UNIDATA STARLOG software. The internal battery will power the logger for up to five years with measurements every ten minutes. An external battery is recommended if more frequent measurements are required.

1.2 Features

■ Wide Application

The WDP is designed for use in typical down-hole applications encountered in well and water bore monitoring. It can also be used to monitor water level in tidal estuaries, streams, lakes, reservoirs, drains and other water bodies where it can be located underwater and below the minimum level to be measured.

The WDP measures depth to the precision and accuracy required for research studies, and has the endurance for long-term monitoring projects. The adjustable log interval provides the flexibility to suit projects ranging from groundwater monitoring (hourly logging for six and a half years) to pump tests (five second logging for three and a half days).

■ Easy to Use

The instrument has been designed for ease of use. Installation involves lowering the instrument to the required depth and fixing it in position. The instrument is commissioned and calibrated at the factory and is fully operational on dispatch. No complex set-up routines, maintenance or calibration is required.

When you connect your computer to the communication port at the surface end of the cable, you can control the instrument and upload the collected data.

■ Simple Operating Software

The Starlog software supplied for your computer is simple to use. This system is used to operate many thousands of instruments, worldwide. A *Scheme* is prepared for each site. This contains all instrument and operational settings. You select your site Scheme from the menu, then:

- To start recording, select Program Logger with Scheme.
- To review the instrument operation, select Scheme Test Mode.
- To retrieve data, select Unload Data from Logger.
- To review or present the logged data, select Display a Data File.

■ Synchronised Data Logging

Each instrument automatically aligns its logging time with the clock. Hourly logging occurs on the hour. Six hourly logging occurs at 0600, 1200, 1800 and 2400. The timing of data collected from a network of instruments is therefore synchronised for improved data analysis and interpretation.

■ Easy to Maintain Power Supply

The lithium battery pack inside the WDP will operate the instrument for five years continuously at ten minute measurement intervals. This battery pack is replaceable and has a plug-in connector. An external battery can be connected to the terminals fitted to the end of the instrument cable. The internal battery will be turned off, but will immediately resume operating if the external power supply fails.

■ Adjustable Specific Gravity

The Specific Gravity (SG) of water changes with its chemical composition. For instance there is a 3% difference between fresh water and seawater. This changes by up to 0.3% with normal temperature changes and this affects the computed depth. The WDP has been set for fresh water at a temperature of 25° C. You can modify this for your site, using the WDP software.

■ Compatible with Other Instruments and Telemetry

The WDP can be used with telemetry systems and can be integrated with other instruments at a site using the built-in SDI-12 communications system. Commercial communication modems can be used to link the WDP to landline, cellular, satellite or radio communication systems. Your local UNIDATA Support Centre can provide advice.

■ Durable and Environmentally Safe

Chemically inert materials are used for all instrument parts in contact with water. These materials will not contaminate natural waters. All instrument materials have been selected for durability and the housing and cable have been designed to withstand arduous physical conditions. The housing is made from marine grade stainless steel and the cable and moulding are made of polyurethane specially formulated for durability in underwater applications. The pressure sensor is sealed behind a stainless steel membrane.

1.3 Models

The WDP is available in 10m, 20m, 50m and 100m ranges. The model numbers are:

Model	Range	Standard Cable Length
8007WDP-12	0 - 10 metres	20 metres
8007WDP-22	0 - 20 metres	30 metres
8007WDP-52	0 - 50 metres	60 metres
8007WDP-102	0 - 100 metres	110 metres

Special cable lengths can be supplied on request.

1.4 System Components

The following components are supplied with each WDP instrument:

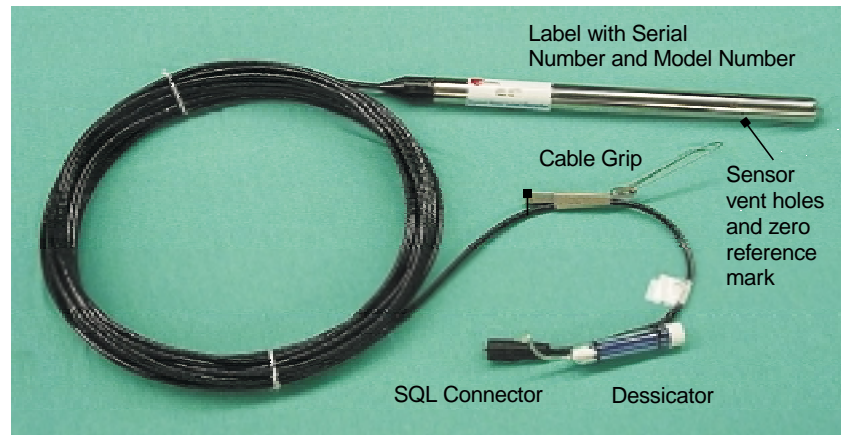
Model 8007A UNIDATA Water Depth Probe Including data logger, lithium battery and cable with a weatherproof plug. The cable length will suit the instrument range.

Model 6603DT <SQL> Drying Tube and Desiccant.

Model 6604A Cable Grip For anchoring the cable.

Model 6603D Adapter Cable For connecting the WDP to a computer and external battery.

Manual 6264 WDP User's Manual (this document).



1.5 Essential Accessories

You will need a portable computer loaded with suitable software to operate these instruments at your field sites. For example a Laptop PC (such as Model 6801) with Model 6301B Starlog V3.09E (or later) software.

If you presently use UNIDATA instruments, you can use the same laptop computer and Starlog Version 3 software. If not, you will need to obtain them.

1.5.1 Laptop Computer Option

■ Suitable Laptop Computer

A laptop computer is required for site operation. The minimum specifications for the computer are:

- 386 processor with 4MB RAM.
- EGA or VGA monochrome or colour screen. The screen should be clearly visible in daylight.
- Hard disk with 10MB free.
- RS-232 COM port available.
- MS-DOS 5 or Windows 9x operating system.
- 3.5" floppy disk drive available to load software.
- Adequate power endurance for field operations. Spare computer batteries or an external battery and power adapter are required.
- Protective case to prevent damage in transit, and from moisture and dust in use.

■ Starlog Software Version 3

The Model 6301 Version 3 Software is used to operate all UNIDATA instruments and retrieve and review data. This can be used with any computer with a DOS or Windows operating system. See *Preparing Schemes* on page 39 for examples of the use of this system.

1.6 Optional Accessories

A range of items that can be required for installation and operation at some sites, can be supplied by UNIDATA.

■ Replacement Internal Battery Pack

The internal lithium battery can be replaced. See the section *Maintenance* on page 61 for details.

Model	Description
Model 6908F	Lithium battery pack. 7Ah. Two 'C' size lithium batteries with harness and plug.

■ External Power Supply

External batteries can be used to power the WDP and conserve the internal lithium batteries, particularly if the project requires detailed data at short intervals. A rechargeable battery and solar panel is normally used at sites where telemetry is installed. The power capacity should be designed to exceed the site requirements. The battery should be housed inside a weatherproof enclosure.

Model	Description
Model 6907C	12V, 12Ah Sealed Lead Acid Battery for external power.
Model 6904C	7W Solar Panel and Mount. To recharge battery.
Model 6904D	12W Solar Panel and Mount. To recharge battery at sites with high power consumption.
Model 6701	Weatherproof enclosure for rechargeable battery.

■ Cable Extensions

If the cable length needs to be extended, UNIDATA can supply standard cables 5 or 10 metres long, and special lengths to order. Vented cable can be supplied to extend both the signal cables and the atmospheric vent.

Non-vented cables extend the signals cables only.

Extension cable fittings are not waterproof and the junction must not be submerged. Extension cables are not load bearing and must not be used to suspend the instrument. A separate stainless steel suspension cable is required. This can be manufactured to the required length or fabricated on-site.

Model	Description
Model 6603V/5 or V/10	<SQL> Connector type 5 or 10 Metre Extension Cable - VENTED.

■ Site Display

The data being measured can only be viewed when a computer is connected. A permanent display can be installed at the end of the cable. This will show the present water depth or level on an LCD screen.

Model	Description
Model 8007WDP/LCD	External LCD display unit. Displays the current water level.

■ Anti-fouling Shield for Sensor

Biological fouling of the face of any strain gauge sensor can result in a distortion of the calibration. A copper screen around the sensor can help prevent this. UNIDATA can supply a copper shield that can be attached to the end of the WDP, or the duct it is mounted in. This surrounds the sensor with copper and reduces the growth of marine animals.

Model	Description
Model 8007 WPD/SHLD	Copper screen. For WDP body or 40mm diameter PVC Pipe. OD 60mm.

2 OPERATING PRINCIPLES

The WDP contains a MicroLogger with a 128K data memory. When powered this automatically runs a factory set program that controls the instrument operation to read the various sensors, perform the mathematical corrections for depth, temperature and sensor mechanics, and log the results to memory when required. UNIDATA Starlog software is used to load a site specific Scheme that contains all the operating instructions of what, when and how data is to be logged.

At each scan the MicroLogger reads:

- The water pressure from the sensor in the WDP. The microprocessor converts this pressure to the calculated depth.
- The water temperature at the pressure sensor. This is used to adjust the sensor calibration when the depth is calculated.
- The battery voltage. This is used to detect and manage low battery situations to preserve the logged data.

All readings will be displayed on any connected computer, and saved for future logging.

At each log interval, some or all of the above readings are saved in the logger memory. When a computer is connected, the Scheme is used to unload the logged information and compute times and scaled data. This data can be presented as data plots, files and listings.

■ Battery Management

Internal lithium batteries power the WDP. These batteries have a shelf life exceeding ten years. The instrument is designed to use very little power when operating. The battery service life exceeds five years at ten minute scans, and ten years at hourly scans. The batteries should be replaced each five years.

Fast scan rates or continuous communications will flatten the battery within days or weeks. To achieve the extended battery endurance, the WDP scan rate should not be less than ten minutes. The Starlog software has been modified to avoid unnecessary communication time. The logger monitors its battery condition and will cease operating and conserve the logged data when the battery is near the end of its service life.

An external battery should be used at sites where rapid logging is required, or telemetry or OEM software is used. The internal batteries will then be in stand-by mode, ready to resume supplying power if the external supply fails.

■ How the WDP Measures Water Depth

The WDP is fitted with a Keller AG pressure sensor. This is used as the source of the water depth and temperature measurements. This pressure sensor is a precision item but has several potential sources of error.

UNIDATA have compensated for these in the design of the WDP. The sensor errors are related to sensor mechanics and the affects of temperature. Algorithms derived from a precise automated calibration procedure at the factory compensate for these potential errors.

Calibration of the WDP is based on digital modelling of 2,500 pressure and temperature measurements, fitted to a five pole polynomial located in the data logger firmware. Fifty temperature points are used to read fifty pressure points that determine the results of a mathematical calibration algorithm. The entire process is automated and is performed on the fully assembled and operating unit, to reduce any possibility of introduced errors. This digital modelling means that each sensor is checked and is compensated not only for temperature variations but also for non-linearity and hysteresis errors.

The pressure sensor reading is converted to water depth using the water column pressure principle, that is, a column of water exerts a pressure at any depth that is proportional to the depth and the specific gravity (SG) of the water. The MicroLogger software computes the water depth using a SG value entered into the WDP firmware. The default SG is 0.9971. This SG is suitable for fresh water at 25°C. You can edit the SG to suit your site. See the section *Calibration* on page 67 for details.

■ How the WDP Derives Water Level

Water Depth is the vertical distance measured by the WDP from the sensor to the water surface. This is of limited value for many studies. Depth is normally converted to a water level when the data is processed, to allow analysis of water tables and flows across a region. The water level is normally referenced to a permanent fixed point at each site, and this point is referenced to a site, project, local or national datum. During a site visit, the actual water level can be surveyed or checked by measurement from the site reference point. This provides a convenient and accurate check for the recorded data.

The WDP uses the measured Depth to produce a record of Water Level (with datum adjustment). This is the sum of the Depth and the value of the level of the WDP sensor zero. If the recorded level does not agree with the check level there is a problem. The sensor zero value is the actual water level at which the WDP sensor, in its measuring location, would measure zero depth. This zero level is entered as the Water Level transducer scaling factor b:. See *Installation* starting on page 21 and *Preparing Schemes* starting on page 39 for more information.

To increase memory endurance the Water Level data is not logged. It is calculated by the Scheme when required for screen displays, plots and data files.

2.1 MicroLogger Operation

The MicroLogger switches on at each scan interval and performs the following tasks:

Measurement At each scan interval the MicroLogger reads the pressure sensor output and the temperature. These signals are then stored in the MicroLogger memory.

Analysis The MicroLogger then performs data processing and analysis of the sensor readings. It uses pre-programmed calibration values for a five point polynomial curve, the measured temperature and the SG of water to calculate the depth.

Communication If a computer is connected to the WDP instrument, the MicroLogger establishes communications via the RS-232 channel. A SDI-12 interrogation sequence will be initialized at this time. The RS-232 and SDI-12 communications will occur simultaneously with other operations.

Data Logging The normal scan is extended as the MicroLogger records the required measurement values into the memory buffer. Here the data remains until the WDP is unloaded into a computer via the RS-232 interface.

2.1.1 Using the WDP

A computer running Starlog Version 3.09E or later Software is required to operate the WDP. A Scheme is prepared for each site. This contains all settings for when, what and how data is to be measured and logged. See the *Preparing Schemes* starting on page 39 for details.

The WDP is installed at your site. See *Installation* starting on page 21 for details.

Once the Scheme is loaded into the WDP, data logging will commence automatically. The same Scheme must be used to unload the data as this contains all the information needed to interpret, process and scale the unloaded data file. See the SITE OPERATION section for details.

The WDP measures water depth and temperature at your selected scan interval (five seconds to six hours) and logs the data at whatever interval you specify, (five seconds to eighteen hours). The logged data is scaled and refined when plots, listings and files are created.

2.2 Factors Affecting Data Accuracy

The WDP instrument is manufactured and calibrated to accurately record the depth of water over the pressure sensor. However there are a range of site and installation factors that can effect the accuracy of the data recorded by any pressure transducer system. The WDP system has the features to either avoid or manage these factors.

UNIDATA provides a comprehensive range of instrument design features, software tools and user information to enable you obtain the best possible data accuracy from your site.

2.2.1 Sensor Movement

If the sensor is moved up and down, the logged water level data will appear to move down, then up. The sensor must be firmly fixed at the required level at your measuring site. This is more difficult when the instrument is suspended. Accurate site checks from a fixed datum are the only way to detect if the sensor has moved. See the *Installation* section starting on page 21 and the *Site Operation* section starting on page 49 for details..

Some causes of sensor movement include:

■ Cable Stretch (elongation)

In a normal cable the weight of the suspended instrument can cause the cable to stretch. This causes an increase in the recorded water depth as the instrument settles into the water. The effect of cable stretch is also related to temperature changes in the cable.

UNIDATA uses a special cable reinforced with a heavy Kevlar strength member that supports the instrument weight. Kevlar does not stretch or change with temperature and age.

■ Cable grip slippage and movement

When the instrument is suspended by its cable, a positioning fitting has to be attached to the cable to take the weight. If this fitting slips on the cable the recorded level will change.

UNIDATA supplies a special two-piece cable clamp that can be fitted around the cable at any location. It is locked in position by a sliding the two tapered parts together. It can be removed and replaced when the instrument is relocated.

■ Removing and replacing the WDP

It can be difficult to replace the instrument to exactly the same location after it has been removed for maintenance.

UNIDATA suggests operating practices to identify and manage these changes.

■ Movement of the mounting structure

Suspended instruments will move up and down with changes to the level of the suspension point or structure. Thermal expansion of PVC or metal bores or well liners, and moisture related changes to wooden structures can be recorded as diurnal changes in water level.

UNIDATA suggests operating practices to identify and manage these changes.

■ Movement of the sensor mount

Sensors fixed in streams or wells can move if the anchoring structure is damaged or subsides. The change will only be noted if site operating practices compare the logged value with an independent water level check.

UNIDATA suggests operating practices to identify and manage these changes.

2.2.2 Water Specific Gravity

All pressure transducers use a water specific gravity factor to convert the pressure to a water depth. In the range of natural waters this SG changes with temperature and water quality. In the case of fresh water by more than 0.5% and in the case of sea water, by up to 3% in seawater. Unless compensated for, this introduces significant errors into the depth. See the *Calibration* section starting on page 67 for details.

UNIDATA supplies your WDP with Specific Gravity set to 0.9971. This suits fresh water at 25°C. You can use the supplied software to change the SG to suit your site conditions.

2.2.3 Calibration Drift or Changes

Each WDP is accurately calibrated before dispatch. During transport and commissioning the instrument will be subject to a range of environmental and physical shocks and changes. These can result in minor calibration changes. See the section entitled *Calibration* starting on page 67 for details.

UNIDATA provides the facility to reset the instrument zero to remove any introduced changes.

In some water conditions mineral or biological growth can gradually accumulate on the sensor. This can change the physical characteristics of the sensor, and hence its calibration.

UNIDATA operating software allows the transducer zero and slope factors to be changed to rescale the recorded data.

3 SPECIFICATIONS

Depth

Overall accuracy: 0.1% Full Scale. This includes the pressure sensor and data logger. As the WDP uses digital communications the cable does not affect system accuracy.

Mathematical precision: 32-bit floating point.

Repeatability: 0.05% full scale.

Operating temperature: 0 to 50° C.

Temperature coefficient: <0.015% full scale per °C.

Operating range: 10, 20, 50, 100, metres of water, depending on sensor range.

Long term stability: 0.1% full scale/year.

Overload pressure: Greater than three times full-scale range. Calibration will be affected only when this is exceeded.

Burst pressure: > 600 metres water depth.

Settling time: Within sixty seconds of immersion.

Pressure sensor: KELLER AG PR9S/80567-2 Piezo-resistive silicon strain gauge bonded to stainless steel membrane (AIS 316L).

Temperature

Sensor: Piezo resistive (integrated with pressure sensor).

Range: 0 to 60°C.

Resolution: 0.1°C.

Accuracy: ±0.5°C.

Data logger

A/D Resolution: 16 bit analogue to digital conversion.

Recording resolution: 0.00033 metres (0.33 mm).

Built in clock: Accurate to ±10 seconds per month.

Measuring interval: Measuring interval will be preset at six hours but is programmable from five seconds to one week.

Time of Log: Automatically aligns to real time. For example 6 hourly logs will automatically be taken at 0600, 1200, 1800 and 2400.

Recording capacity: 60,000 records can be logged into memory.

Memory management: The memory can be set to roll over (endless loop) or recording can be stopped when the logger is full.

Data unload security.: Unload files are automatically tagged with the site name.

An optional comment can be attached before unloading.

Password protection is optional for the DRS and this prevents accidental erasure of the memory.

Power supply: 'C' size 3.4V Lithium battery (x 2). Capacity 7.2 Ah.

Battery shelf life: 10 years.

The batteries are located in the down-hole instrument housing. UNIDATA supplies these batteries in a special assembly with a connection plug. Competent technicians can replace batteries.

Power endurance: >60 months battery life at one recording per ten minutes.

Data offload power use: >500 data offloads can be executed on a completely filled memory during the specified battery life.

External power: 9V to 15VDC, 60mA measuring, 25uA standby.

Over-voltage protection: Zener diode barrier protection is fitted to all signal and power lines. In addition the signals lines have 1.5kV ESD protection.

Memory type: 128k Static RAM (volatile) with Lithium battery backup. The memory is backed up by the main batteries that have a five year life. Retrieval of data must occur before replacement of main batteries.

Communication interface: RS-232C for PC to WDP connection. An optional isolation interface for additional protection for the DRS and WDP is available.

Data rate (Baud Rate): Enhanced RS-232 drivers - 300 to 78,600 baud. Meets IEEE specifications into 20nF load at 10,000 Baud. Acceptable to use 250m cable (no detectable errors into 500m data cable at 9600bps).

Communications protocol features: Bi-directional communication checksum error checking feature for reception of data from the WDP and transmission of commands to the WDP.

Complete control of all the WDP features including data retrieval, data commands, WDP programming requests etc.

The WDP processor will not accept incorrect commands (i.e. a command that has an erroneous checksum) and the STARLOG data retrieval software will not accept data from the WDP that is erroneous (i.e. a data stream that has an incorrect checksum).

The communication system used by the WDP is suitable for the cable length supplied with the WDP. The total maximum cable length is limited to the standard for RS-232C communications (150 metres).

Enclosures

- Features:** The data logger and sensor are enclosed in a corrosion proof 316 stainless steel housing. All housing materials and all combinations are corrosion proof. The WDP is designed for continuous submersion. The cables and fittings are suited for permanent field installation.
- Dimension:** Diameter 40mm. Length 600mm.
- Material:** AIS 316 stainless steel.
- Mass:** 2.1kg plus cable.
- Operating temperature:** 0 to 50°C.
- Humidity:** 0 to 100% RH.
- Ingress protection:** IP68 type designed for permanent submersion to <100m.
- Cable entry:** The cable entry is moulded from a specially formulated polyurethane compound (70A hardness) with an expected lifetime in excess of ten years. Water blocking is fitted to prevent ingress in the event of cable jacket rupture.

Above water parts

- The cable plug is provided with a weatherproof sealing cap. Cables and fittings are suited for an operating temperature of 0 to 50°C with 100% humidity.
- Connector (SQL):** High quality, weatherproof circular connections provided with a secure screw interlocking shroud.
- Protection standard :** IP65.
- Contact rating:** 6A at 250VAC, 300VDC.
- Contact resistance:** >10Ω (after 4 days at 20°C and 80% RH).
- Dessicator:** Length 150mm. Outside diameter: 20mm. Capacity: 30gms of Silica Gel.

Cable - Physical

- The cable supplied is flexible within the specified temperature range. The minimum coil diameter is 0.5 metres.
- Cable length:** Range plus 10 metres. Special lengths to order.
- Outside diameter:** 8.7mm.
- Jacket thickness:** 1.01mm.

- Jacket material:** Abrasion Resistant Polyurethane (Black Colour).
Jacket hardness: 80A.

Cable - Conductors

- 5 x #24 AWG tinned copper (7/0.2) with polypropylene insulation (0.275" thick).**
- Shield:** >90% braided tinned copper (#36 AWG).
- Characteristics:** 50pF per metre, 10Ω per 1000m.
- Strength member:** 2mm OD stranded Kevlar.
- Temperature coefficient:** Longitudinal change 0.00048 mm/m/°C.
- Cable entry:** Specially formulated polyurethane compound (70A Hardness) designed to compress more than the cable under pressure.
- Water blocking at cable access :** Polyurethane potted entry (wires barred).
- Vent tube:** Nylon 1 mm I.D. 0.4 mm wall thickness.
- The cable is fitted with a moveable flexible cable grip. This can be attached to a fixture to suspend the WDP. A UNIDATA SQL connector is fitted to the cable end. The vent tube is fitted with a silica gel filled breather apparatus.

Factory Settings

- Scan rate:** 1 hour.
- Log interval:** 1 hour.
- Data to be Logged:** Water Depth, Water Temperature, Battery Voltage. Water level is derived from Depth.
- Logging Resolution:** 1mm for instrument ranges to 65 metres.
2mm for instrument ranges to 130 metres.
- Memory:** Linear (no overwrite).

Battery Duration Table

Scan Rate		
5 min	10 min	1 Hour*
30 months	60 months	>120 months

* factory setting.

Battery shelf life is 120 months maximum.

Due allowance must be made for frequent interrogation by computer/modem.

Memory Duration Table

Parameters recorded	Endurance in days at various log intervals		
	10 min	1 hour*	6 hours
Depth	416 days	2500 days	15000 days
Depth and temperature	208 days	1250 days	7500 days
Depth, Temperature and Battery	139 days	833 days	5000 days

*Factory setting.

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4 INSTALLATION

4.1 Planning Long Term Projects

The WDP can measure accurate and reliable water level data for long periods. Project planning, site selection and design, and instrument installation and operation will determine whether your data collection commitment is successful. It is not possible to collect good data from an unsuitable or poorly designed site.

At the planning stage, the general objectives of the project and the specific requirements of each site should be clearly defined. The sites can then be selected and designed to suit these objectives, the instruments selected to suit the sites and the operating strategies implemented to achieve the required data quality. As data collection progresses the results can be regularly reviewed and the sites and operating strategies modified as required to meet the objectives. A focus on regular data analysis and reporting of results will maintain the relevance of the project and achieve the maximum benefits.

4.2 Designing the Installation

The following are some of the issues to be considered in the site selection and design at all sites. Specific issues relating to Groundwater and Surface Water sites are discussed in the following sections.

4.2.1 Site Requirements

These are:

- The site should be suitable for measuring the required data range.
- It should be accessible for regular maintenance.
- There should be a safe working environment for staff.
- The measuring structure should be stable for the life of the project and not move vertically with time.
- There should be a secure, dry and clean instrument housing if there are accessories such as external power and telemetry at the site.
- The water level within the measuring structure must be the same as the aquifer or water surface of interest, and follow the external changes.

4.2.2 Instrument Requirements

These are:

- The instrument range should span the full range of water level variations to be measured at the site.
- The WDP must be located at a fixed point below the minimum water level of interest.
- The WDP should be able to be removed and reinstalled to the same position.
- The WDP cable dry end should be kept clean, dry and protected from damage or interference.

The WDP will not be damaged if it is out of water, or if its measuring range is exceeded (provided the plug at the end of the cable does not go underwater). However you will not record any out-of-range data. In the natural environment it is often the maximum and minimum values that are of the greatest interest.

4.3 Installation Issues

4.3.1 Housing the Instrument

The WDP should be installed in a way that protects the instrument and cable from accidental damage, interference or vandalism, or deterioration caused by insect or animal attacks or by abrasion from continual water movement.

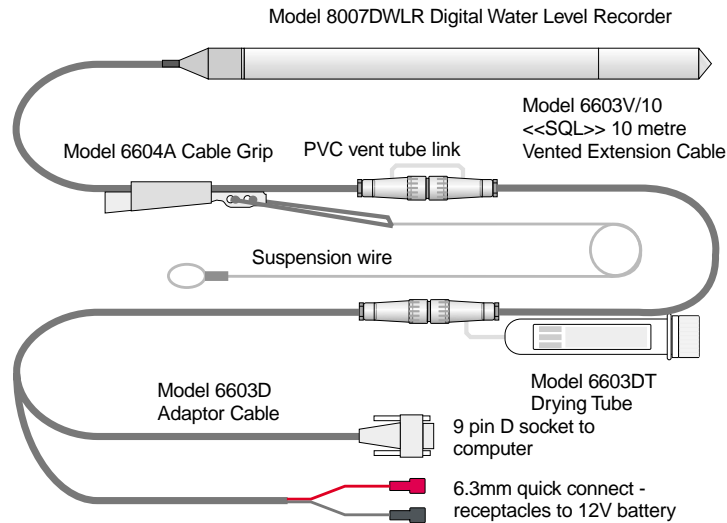
The drying tube, computer connectors and any battery should be located inside a weatherproof enclosure such as a UNIDATA Model 6701. The enclosure should not be completely sealed, as the drying tube needs to vent to the atmosphere and the sealed lead acid battery can also vent gas during an overcharge condition.

4.3.2 Selecting the Cable Length

Normally the instrument is suspended from its cable, using the clamp supplied and with the end plug above ground level where it can be connected to your computer. This allows you to check the instrument while it is operating and recording the water level. You will need to order cable lengths to suit each site.

4.3.3 Extending the Cable Length

If the cable is too short, use a suspension wire to position the WDP deeper into the water. Use a UNIDATA vented extension cable to extend the computer connection and desiccant to the surface. Do not suspend the WDP from the extension cable, or submerge the cable joint. The extension cable is not load bearing and the connections are not waterproof.



4.3.4 Cable Connections and Extensions

The WDP includes a vented, multicore signal cable, which is terminated into a 7 pin <<SQL>> weatherproof connector. This cable can be extended with UNIDATA Model 6603V extensions to a maximum total length of 120 metres. The following connections are used.

WDP Cable Connections Table Nine Wire Vented Cable			Computer Socket		MODEM Plug
SQL Pin#	Wire Colour	Signal Description	D25	D9	D25
1	Red & Orange	+12V Battery +ve	-	-	9 +12V*
2	Yellow	RxD(OUT) RS-232 serial data from WDP	3	2	2 TXD(IN)
3	Black	TxD(IN) RS-232 serial data to WDP	2	3	3 RXD(OUT)
4	White	RTS(IN) Request to Send	4	7	8 CD(OUT)
5	Purple	SDI-12 Data In/Out - HSIO Clock and - Counter 0**	-	-	22 RING(OUT)
6	Blue	Not used	-	-	Not used
7 cntr	Green & Brown	GND Battery -ve/signal ground	7	5	7 GND

*Model 6802C Micro power Modem connections.

**When in counter mode, only voltage pulses of 7.5V will be recognised.

4.3.5 Drying Tube and Desiccant

The WDP cable contains a vent tube to reference the pressure sensor to atmospheric pressure. It is very important to ensure that NO MOISTURE enters the vent tube. If the tube is blocked, erratic depth measurements may be recorded.

The WDP connector vents the cable to the atmosphere through a drying tube (Model 6603DT) containing silica gel desiccant. Do not locate the tube in an area subject to moisture or artificial pressure changes. Open the vent on the drying tube. Replace or regenerate the desiccant when it changes colour from blue to pink. See the section entitled Maintenance starting on page 61 for more information.

4.3.6 Power Considerations

The instrument is designed to operate from internal lithium batteries for five years, and record hourly measurements. It can be adjusted to log more frequently and to use telemetry. The power consumption will increase and the life of the internal batteries may be reduced to a few weeks. An external power supply should be connected and this will rest the internal batteries.

If the WDP is to be externally powered, a 12VDC source capable of supplying a max load of 100mA is required. The battery leads are part of the UNIDATA Model 6603D cable supplied with each WDP for computer communications.

4.3.7 Telemetry

The WDP connects directly to a standard data modem. This allows you to examine real time readings and unload recorded data from your office over a standard telephone line, or cellular or satellite phone network.

The preferred modem has the following characteristics:

- 12VDC operation with low power modes (Micro power standby mode).
- Power ON with RING DETECT and DTR.
- At least 2400 baud communication rate.
- MNP Class 2-5 and CCITT V.42 bis data compression and error correction.
- 9600 baud computer interface.
- Suitable for switched network or cellular phone operation.

Several brands of modem are available. Contact your nearest UNIDATA supplier for more information.

When communicating with a WDP via modem, both the WDP and modem remain switched on and the WDP consumes many times its normal operating power. You must use an external battery and a charging system. If the battery is solar charged, the size of the battery and solar panel should be selected to suit the site and project.

4.4 Groundwater Monitoring

4.4.1 Groundwater Site Design Issues

It can be difficult to estimate the possible range of ground water level variation in a bore or well. This will be related to the natural topography, geology, rainfall and water use. There may be several layers of groundwater at different levels, and each of these aquifers can change in different ways. In bores close to high volume pumping, large and unpredictable level changes can occur.

The design and construction of a bore will influence the standing water level. In larger bores the casing is normally sealed at the bottom and slotted or screened at a particular depth to allow water entry from the aquifer of interest. Leakage down the casing from surface runoff or higher aquifers may effect the standing water level within the bore. In a natural region with alluvial soils such as a river valley, the shallow water table frequently underlies the landscape as a flat plane with a gentle slope toward an outlet in a stream or the ocean. The level will change slowly and the range of changes will be similar across the region with minor variations due to local water consumption.

If you are not sure of the expected range, seek information from local groundwater users or experts. Review data from any monitoring at nearby sites. Select an instrument range that exceeds the expected water level variation. Position the instrument well below the minimum expected water level. You may need to vary the instrument position as the seasons change.

4.4.2 The Groundwater Measuring Structure

- The bore screens or inlets that allow water entry should be functional. The level of the lowest inlet will determine the minimum relevant recording level.
- Surface run off and leakage down the outside of the casing should be prevented.

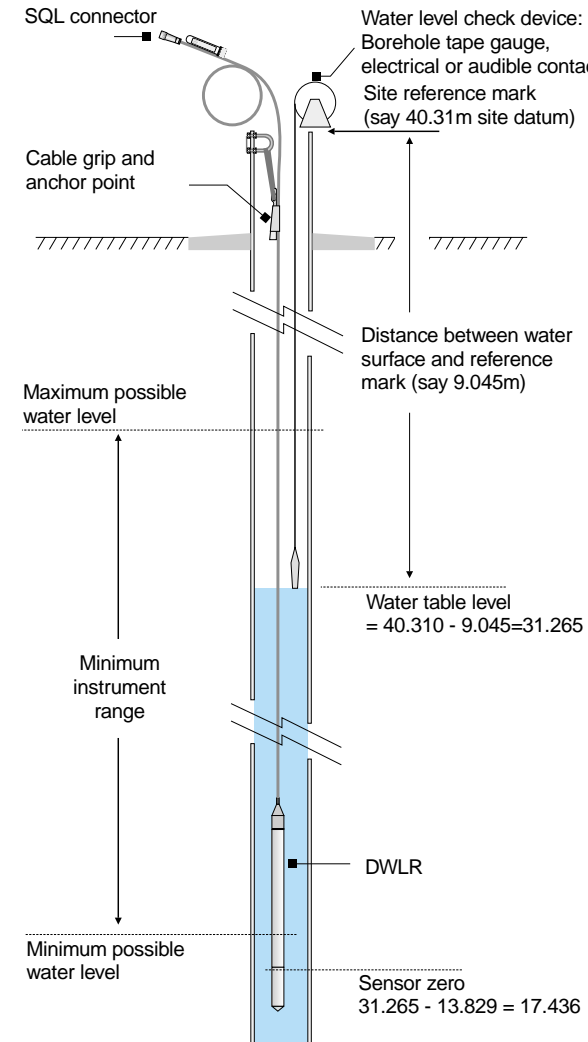
- The inside diameter of the bore must be clear and smooth and at least 50mm diameter.
- If there are obstructions with the bore or well that might trap or jam the WDP, consider installing a 50mm PVC pipe insert as a mounting tube for the WDP.
- A permanent suspension point is required to suspend the instrument.
- A Reference Mark should be installed at the top of the well or bore casing, vertically over the water surface.

4.4.3 The Reference Mark

The WDP can be installed in any vertical bore or well. A permanent reference mark is required at the top.

The reference mark is allocated a level. This may be from an assumed datum, eg. 100.000 metres Assumed Datum. This mark can also be surveyed to a project datum eg. 40.310m. A common datum is essential if you wish to compare the water levels at different sites within a project.

The vertical distance between this mark and the water surface is measured at each site inspection. At installation the level of the water surface can be calculated and the WDP set to record this level. At all future checks the measured water surface level can be checked against the recorded level.

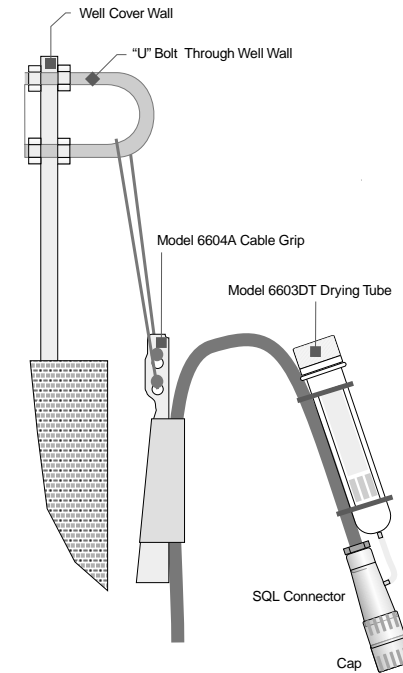


The level of the top of the bore or well can change if the structure settles or rises. This will effect the water level recorded by the WDP. A check survey of the reference mark should be carried out annually. Use a stable local Bench Mark or other independent reference mark to confirm that site reference mark (and the WDP anchor point) is stable. Any significant verified changes should be applied to adjust the recorded data for the period.

4.5 Installing the Instrument

The cable grip should be attached to the anchor point, using a small stainless steel shackle, or the mounting loop that forms part of the grip assembly. To install the WDP follow the steps below:

1. Check the well for obstructions. Measure the bore depth and the present water level using a bore hole tape gauge. Decide on the level at which the WDP is to be installed and the distance from the mounting loop to the instrument location.
2. Unwind the cable and lay it on the ground. Take care not to damage the cable. Always handle the WDP cable coil gently. Measure the distance along the cable from the WDP, and then fit and lock the mounting clamp in position.
3. Carefully lower the WDP into the well. As you lower the WDP, avoid twisting or kinking the cable. Do not allow the cable to rub against sharp surfaces or angles.
4. Keep the WDP above the bottom of the well or bore. The sensor ports may be blocked by fine silt.
5. When the WDP is lowered to the desired level attach the clamp to the mounting point.
6. Ensure that the desiccator crystals are blue and remove the seal to expose the vent hole. Ensure that the desiccator is not in an area of excessive moisture or variable pressure.



Suspending the WDP

4.6 Commissioning the Site

Connect your computer, start the Starlog software and select the site Scheme.

To calculate the sensor zero value see the illustration in *Setting the Sensor Value* on page 34:

1. Measure the distance from the reference mark to the water surface with an electrical contact tape, or similar device designed for water level measurement in boreholes. Calculate the water level check by subtracting the tape distance from the reference mark value. $40.31 - 9.045 = 31.265$.
2. Read the depth from the computer display in Scheme Test Mode. Calculate the zero level of the WDP sensor by subtracting the recorded depth from the water level. $(31.265 - 13.829) = 17.436$.
3. Edit the site Scheme to enter the sensor zero value (17.436) to apply to the Water Level Transducer.

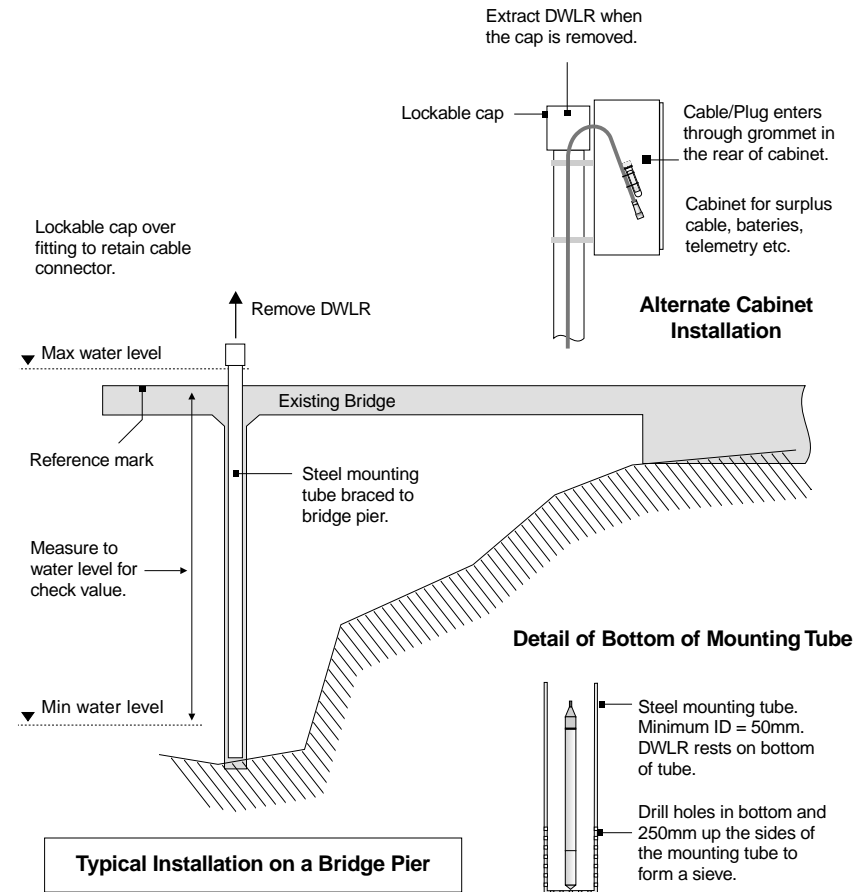
- Save the Scheme and then Program Logger with Scheme. Select Program Logger with Scheme and the reset will be automatic.

The Scheme will be loaded and logging will commence automatically. Logging will continue uninterrupted and you can review, unload and display the data as often as required. Logging will only “stop” the next time you select Program Logger with Scheme at which time the logger is reset and all old data is lost.

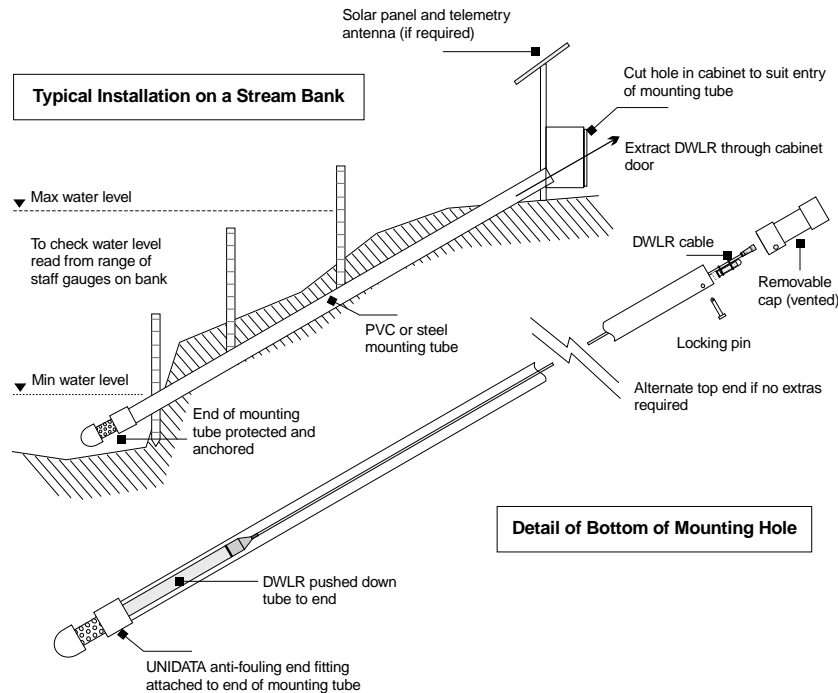
Open the Scheme Test Mode screen. The displayed Water Level should now be the same as the calculated check level.

4.7 Surface Water Monitoring

In rivers and streams the minimum level of interest is typically the level at which the water stops flowing in the channel. The maximum is normally the highest possible flood level and this can be estimated from floodmarks, landscape features such as flood plains, or the local knowledge of long time residents.



A suitable structure is needed to position the WDP at or below the minimum water level, the cable end above the maximum water level, and to protect the cable from damage. It should be possible to remove the WDP for servicing and to return it to the same level.



A vertical or sloping tube can be used for an instrument mount. A steel pipe with a minimum diameter of 40mm can be attached vertically to a bridge pier, dam wall, or to the side of a tank. The pipe may be laid sloping down the stream bank and attached to solid anchors. The bottom can be capped and drilled as a sieve to allow water into the tube and reduce the effects of velocity.

The WDP can be lowered down the pipe to rest in the bottom. The top of the tube can be capped with a vented cap and should be locked if security is required. If there is surplus cable, other instruments, or a power supply at the site, you will need an instrument cabinet.

In seawater or other corrosive environments use a PVC pipe to reduce corrosion. Fasten the Model 8007 WDP/SHLD copper sieve to the end as a cap. This will help to prevent marine growth on the sensor.

4.8 Water Level Check Facilities

It is essential to provide the facilities to obtain a check water level at the site. For example:

- If there is a bridge or other structure over the water surface, establish a reference mark and survey it to the project datum. Measure to the water surface to obtain a check reading.
- On sloping stream banks a range of staff gauges may be established and surveyed to the site datum. The water level check can then be read from these gauges. The gauges should be regularly checked and maintained as some movement may occur.
- The water surface level may be surveyed or measured from reference points located up the stream bank.

The same techniques are used to operate surface and groundwater sites.

4.9 Setting the Sensor Zero Value

The Sensor Zero Value is the level of the WDP sensor, referenced to the site datum. When entered into the WDP Scheme for the site, all water level values will be reported as site datum. At some surface water sites this value can be measured or surveyed directly when the instrument is first installed. At other sites the WDP may not be accessible and the value can be obtained directly by the same technique used for groundwater sites.

To set the zero value:

1. Connect your computer, start the STARLOG software, and then select the site Scheme and Scheme Test Mode.
2. Survey, measure or calculate the sensor zero value. To calculate the sensor zero value see the illustration on page 28.
3. Measure the distance from the reference mark to the water surface with an electrical contact tape, or a similar device designed for water level measurement in boreholes. Calculate the water level check as the reference mark value - the tape distance. At surface water sites the water level may be surveyed, or read from the site staff gauges.

4. Read the depth from the computer display in Scheme Test Mode. Calculate the zero level of the WDP sensor by subtracting the recorded depth from the water level.
5. Edit the site Scheme and enter the sensor zero value to apply to the Water Level Transducer.
6. Save the Scheme. Select Program Logger with Scheme. The remaining processes will run automatically.

4.10 Reset Zero and Offset Adjust

A new facility has been provided in the V3.09 Rev E software to enable you to Zero the WDP reading prior to installation.

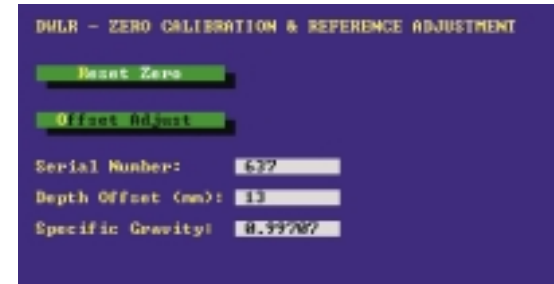
If you are using an earlier version of the V3 software, then update your V3 system with the files on the diskette labelled WDP Reset Zero Update.

When you Create a new Scheme or Save an existing Scheme, a new menu item labelled Reset Zero & Offset Adjust will appear.

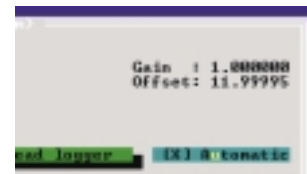


To use this function, do the following:

1. Mount the WDP instrument in a vertical position (cable end up) and let it stabilise for 10 minutes.
2. Connect the WDP instrument to your computer and select the Reset Zero & Offset Adjust menu item. Select the Reset Zero menu item (shown below).



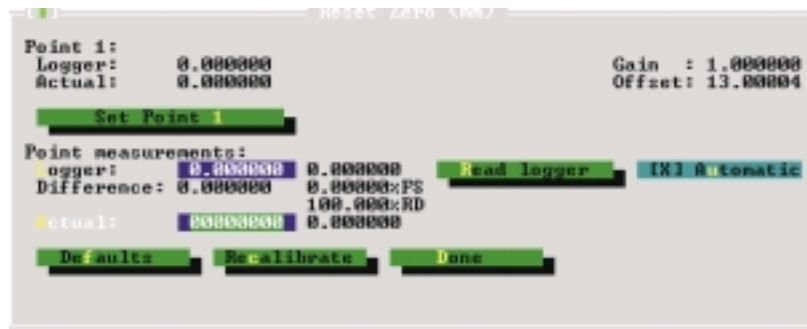
3. If the Gain and Offset calibration settings do not read 1.0000 and 0.0000 respectively, then select Defaults (Alt+F) to reset them.



4. When the Logger reading stabilises, select Set Point 1 (Alt+1) to Reset the Zero reference, followed by Recalibrate (Alt+C) to recalibrate the WDP instrument.



- Confirm that the Logger reading is now zero and select “Done” (Alt+D) to exit calibration mode, then Exit (Alt+X) to return to the Scheme Menu.



4.11 Check and Test the Logger Operation

The Scheme will be loaded and logging will commence automatically. Logging will continue uninterrupted and you can review, unload and display the data as often as required. Logging will only stop the next time you select Program Logger with Scheme, at which time the logger is reset and all stored data erased.

As this is a test, open the Scheme Test Mode window. The displayed Water Level should now be the same as the calculated check level. Raise the WDP and the displayed water level should fall. Lower it back into place and the reading should return to the original level.

When you are satisfied that all is OK, select Program Logger with Scheme. The logger will be reset and all test data erased. The logger will automatically begin logging the water level at your site.

Logging will continue uninterrupted until the next time you select Program Logger with Scheme at which time the logger is reset and all old data is lost. You can review, unload and display the data as often as required.

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5.5.1 Windows Menu

Menu Item	Description
General	Site name to be displayed as the title on data plots, listings and outputs.
Communications	Select your computer communications settings. Enter telemetry communications set up for any site modem.
Instruments	Modify instrument details and sensor scaling and offsets to suit your operations at this site.
Program 1	Set Scan and Log intervals and averaging.
Log Buffer 1	Select the data to be logged.
Events	Not used for this application.
Area Rating	Not used for this application.

5.5.2 Editing Communications

To define the serial port parameters and whether the logger is connected to a modem or computer, you must make entries in the Communications dialogue (select Window | Communications if it is closed).

To a computer, you must select the port to which the logger is connected and set the baud rate. These settings must match those used on the computer.

If you are communicating through a modem, select Via Modem, and then enter the phone number the modem must dial in the Phone: ATD response. If the modem requires a control string, enter it in the Setup: AT response.

5.5.3 Editing Instruments

Select Window | Instruments | Edit from the menu. An Instruments panel will open. Double-click on the line 8007 ... and a description screen will open. This details how the measurements from the WDP are scaled and presented on your computer screen, plots and files. The WDP Instrument has four transducers. It measures Water Depth, Water Temperature and Battery Voltage. It also adjusts the measured depth to a Water Level using a site specific datum adjustment that you enter.

Click on any Transducer to see the scaling and presentation parameters associated with that device.

5.5.4 Editing Water Depth And Water Level (with datum adjustment)

Depth is the distance from the sensor to the water surface. For many projects the Water Level is required in terms of a site, project or national datum. Water Level (with datum adjustment) is the sum of the Depth and a specified offset.

When you click on Transducer 1 or 3 (see the illustration above) a dialogue box with the parameters associated with that transducer are recorded as shown in the example on the following page.

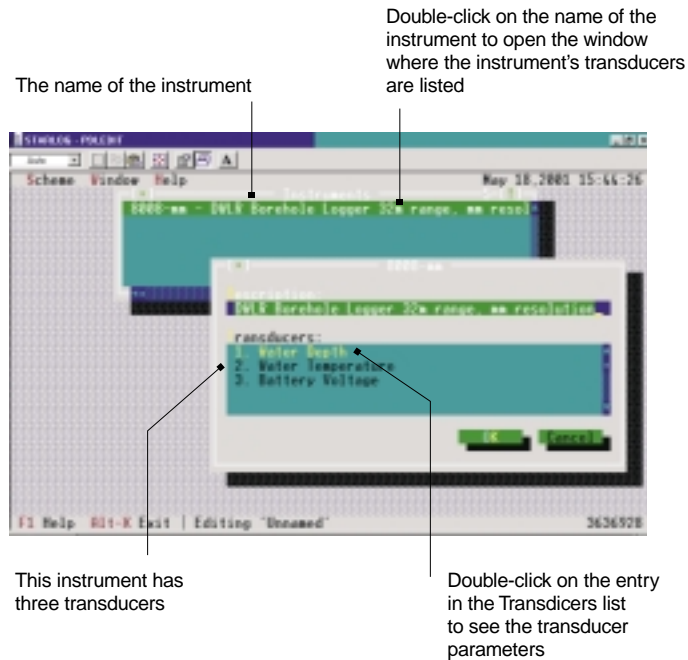
Edit the Scale value for a: to adjust the scaled output values in reports:

- to compensate for a change in the calibration slope of the transducer, and/or,
- to adjust the maximum range to suit a WDP instrument with a range >65 metres.

Edit the Scale value b: to adjust the scaled output values in reports:

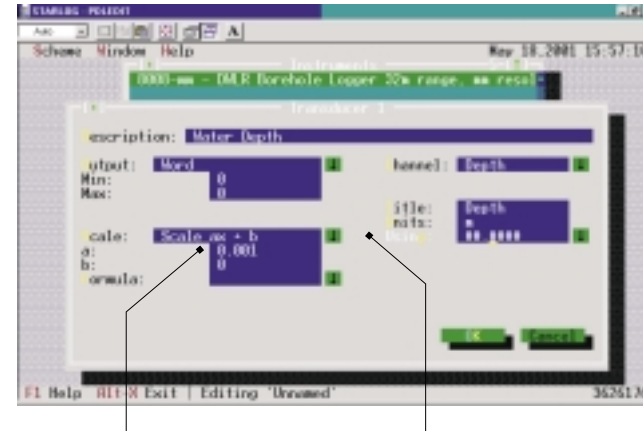
- to compensate for a zero offset change in the transducer, and/or
- to enter a datum adjustment to adjust the depth to a level in the water level transducer.

The default values for most sites will be a: 0.001 metres and b: 0 metres. You can change these if your data and calibration checks indicate an adjustment is required. See the section entitled *Calibration* page 67.



5.5.4.1 Editing Depth Scales

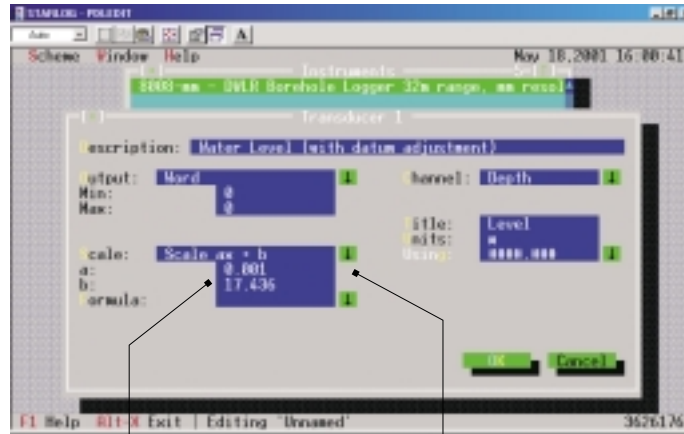
Using the default values the instrument can display a Depth range from 0 to 65.535 metres, to a resolution of 1mm. Edit Scale a: if the Depth range is expected to exceed 65.535 m. The resolution will be reduced.



Scale a: Setting	Measuring Range (m)	Resolution (mm)
0.001	0 to 65.535	1mm
0.002	0 to 131.070	2mm
0.005	0 to 327.675	5mm

5.5.4.2 Adjusting The Depth To A Water Level

The measured depth is automatically converted to a level, using a default datum adjustment of 0.000m. This value may be adjusted to suit your site.



An additional level offset value may be added to b: to convert Depth to Level.

The same a: and b: values as for the Depth transducer are entered here.

For example the water level at your site may be surveyed using your project datum as 31.265 metres. If the instrument depth displayed in Scheme Test Mode is 13.829 metres, there is a difference of 17.436 metres. If you enter the difference in b: in the Transducer dialogue, the Water Level data will be displayed as 31.265m and the depth data will be displayed as 13.829m.

5.5.5 Selecting When and How to Log Data

Open this window to select details of the timing of the data to be measured (Scan Interval) and recorded (Log Interval).

Internal batteries with a very long shelf life are a special feature of this instrument. The selected Scan rate will determine the service life of these batteries. The minimum recommended scan rate is ten minutes. The default setting is one hour. These slower rates are suitable for studies where the water level changes slowly. For projects such as pump tests and studies where rapidly changing variables are measured, scan rates, to five seconds may be used. For any scan rate less than ten minutes an external power supply should be connected to prevent the premature discharge of the internal batteries.

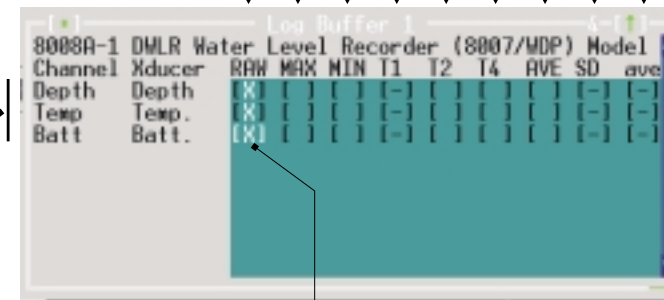
The Log Interval can be any logical increment of the Scan Rate, up to 18 hours. The average of all scans (AVE), or the latest scan (RAW) may be logged at each Log Interval. The Sub Interval introduces another measuring option where a specified number of scans at the end of Log Interval may be averaged (ave) before being logged.

5.5.6 Selecting What To Log

The Log Buffer 1 Window is used to select any data you wish to log. All options are displayed as a table. You use the spacebar to toggle each required option on and off. Each selection will log each Log Interval.

The memory capacity is 130,000 bytes. Each reading occupies 2 bytes. The memory endurance can be calculated based on the total number of bytes in each log, and the Log Interval.

These are the options for how the data may be logged each Log Interval



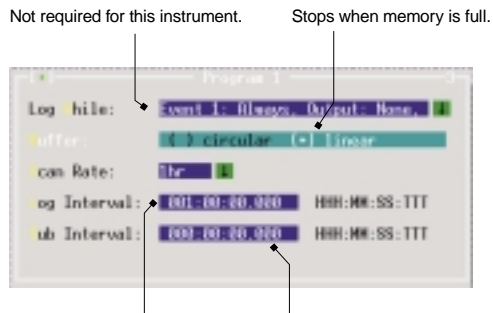
These are the transducers that can be logged

The X indicates that the operation is selected

5.5.7 Selecting When To Log

When you have finished editing all details, name and save the Scheme. Changing scheme names is covered in *Edit The Scheme Name To Suit The Site* on page 40.

Select Scheme | Save As and enter a suitable name for your site. Select Alt+* to exit. Your new scheme will now be listed in the scheme menu from where you can select and use it.



Key in the Log Interval. Must be an increment of the Scan Rate and be less than or equal to 18.

If there are multiple scans in a log period, some may be averaged then logged. Key in the averaging time period.

Select the Scan Rate from menu. Use external power when the Scan Rate is set to be less than 10 minutes.

Scan Rate	Battery Life	Use
5s	1 month	No
15s	3 months	No
1m	1 year	No
10m	5 years	Yes
30m	5 years +	Yes
1hr	5 years +	Yes
6hr	5 years +	Yes

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6 SITE OPERATIONS

The purpose of installing and operating the site should be clearly understood by present and future staff. A written statement of objectives will allow the site operation to be designed to suit the project.

For example:

“this site is part of a network of five sites established as part of the project, to monitor the effects of on the groundwater levels in the region. Data is required for a period of ten years and the objective is to monitor the annual range of water levels, and the effect of seasonal water use and local rainfall on the aquifer. Data should be recorded hourly to an accuracy of +/-10mm. An annual plot of all data and a summary of issues should be supplied to by each year”

Once collected this data may be used for a range of process, management and environmental purposes, sometimes in unexpected ways. It is important that the site be operated to a consistent standard by staff with a basic understanding of data collection and management.

Although the instrument can operate for up to five years, the site may be interfered with or damaged at any time, and may deteriorate to an unacceptable condition within a few months. Regular site inspections and equipment servicing is essential. Groundwater sites should be inspected and serviced at least annually. Surface water sites should be inspected at least each 3 months. More frequent visits will improve data quality and reduce any data loss.

The purpose of each site inspection is to check that the present data is accurate and to fix any problems so that this will continue. Experienced site operators carefully plan for the site visit, allowing sufficient time to complete all work, and ensuring they have all the equipment, information, tools and materials they will need. A project report form and checklist is normally used to record details of the site visit. Instrument manuals, documents, site access details, special instructions and visit reports should be kept in a site file, and taken to the site each visit.

Data should be regularly recovered from each site and securely archived in a data management system that will permanently preserve the raw data. This data should be reviewed and edited to adjust any anomalies or errors, and saved as an archive for future analysis and use.

6.1 Preparing For a Site Inspection

6.1.1 At the Project Depot

Each successful site inspection starts well before departure from your depot. Careful planning and preparation is essential. Consider each site and each task to be done. Think through each process and the special tools, materials and equipment you may need. Prepare a list of things you will need. If you are not confident about some tasks, seek help, advice and training before you go. Ideally, set up test instruments at your depot and use these to simulate your site inspection.

Consider the expected weather and site conditions. Staff must have adequate protective clothing, shelter and sustenance to work safely and comfortably at the site. Your computer and instruments must be protected against moisture, excessive heat and dust. All equipment must be packed well to prevent damage in transit.

Expect a small percentage of instruments to be found damaged or faulty. It is not possible to repair a faulty instrument component at the field site. Your only option is to exchange the instrument. You should carry spare instruments, and these must be operational and in good condition.

Experienced operators will do the following when preparing for a site inspection:

- Check the report from the previous site inspection. Plan to complete all the work that is required.
- Prepare the test equipment, spare instruments, materials and tools you will need. Check all are functional and in good condition.
- Check your computer. Confirm you have the correct software, the Scheme for each site and the correct communication cables. Check that you have adequate power supplies to complete all site visits.
- Check and adjust the computer time and date. This will be used to reset the logger.
- Carry spare battery packs for all instruments, and your computer.

- Take the site inspection file.

6.1.2 At the Site

At the site your objectives are to:

- recover the recorded data and verify its quality, and
- ensure the next period of data will be of good quality.

At times it will be better to do nothing, and to return another day. For example if it is raining heavily and the site has no protection, you will damage the instruments and your test equipment if they get wet. Rushing through a site visit, or trying to use a faulty computer, can also cause problems.

When you proceed, prepare a comfortable and safe work environment for yourself, lay out the tools and equipment you will need. Work through your visit in a logical sequence, such as suggested in the following section. Fill in a report as you go and complete one part of the procedure before proceeding to the next.

If you encounter a problem, think logically through the process and carry out checks and tests to eliminate probable causes. Note down any error messages displayed on the computer. It is important to identify the real problem so it can be fixed. Check the most obvious things first. For example, is your computer connected properly and are the instrument batteries OK? Do not jump to conclusions.

Do not fiddle with things that are OK. If it is working well, leave it alone.

6.2 Carrying Out a Site Inspection

6.2.1 Initial Inspection

Before touching anything, inspect and note the condition of the site, installation and instruments. If you notice any problems try and work out what has happened and how to prevent it recurring. Check if the site is complete and for any signs of damage or interference. Also, take a check measurement of the water level.

6.2.2 Reviewing Current Logger Operation - Scheme Test Mode

Connect your computer to the data logger using the UNIDATA cable supplied. Start the Starlog software.

Select the site Scheme. Select Scheme Test Mode from the Scheme menu.

The screen that appears shows all details of the current logging situation. To conserve power this display is updated once only as the screen opens. To refresh the display, close the screen (Alt+X), then re-select (T). You can use this screen as often and for as long as you like, as logging continues normally.

- Note the logger time and date and compare any difference with real time.
- Note the logged water level, temperature and battery voltage. Compare these with site checks.
- Note the memory remaining. Estimate the expiry date.
- Scan the recent data listed. Look for any anomalies that may indicate faults.

The screenshot shows the Starlog software interface. The top menu bar includes 'Screen', 'Logger', 'BATT', 'Options', 'Window', and 'Help'. The main display area shows the following information:

```

Scheme Name: DMLBLOG          Depth: -0.001 m
Logger State: Logging         Level: 99.999 m
Scan Rate: 60 min            Temp: 24.47 degC
Log Interval: 60 min         Batt.: 6.60 V
Log Size: 6 byte
Free Memory: 118 K
Now: 23 Jan 01 15:36:00
Start: 23 Jan 01 12:00:00
Last: 23 Jan 01 15:00:00
  
```

Below this information is a table of logged data:

Time	RAW Depth	RAW Level	RAW Temp	RAW Batt.
	m	m	degC	V
23 Jan 01 12:00:00	-0.001	99.999	25.96	6.75
23 Jan 01 13:00:00	-0.001	99.999	25.44	6.75
23 Jan 01 14:00:00	0.000	100.000	25.41	6.75
23 Jan 01 15:00:00	-0.001	99.999	24.94	6.75

The bottom status bar shows 'Alt-X Exit F1 Help Alt-C Open Comm COM1:9600,N,8,1 13075456'.

6.2.2.1 Recovering Data - Unloading Data from Logger

From the Scheme Menu, select Unload data from Logger. The following screen will open. All data recorded since the logger was programmed will be unloaded and saved automatically. The U (unload) file will be saved into your Schemes folder, named with the Scheme name and an extension U##. This extension number increments automatically. Data may be unloaded as many times as required. At each unload you will create a new file and recover all the old recorded data, plus the latest.

```

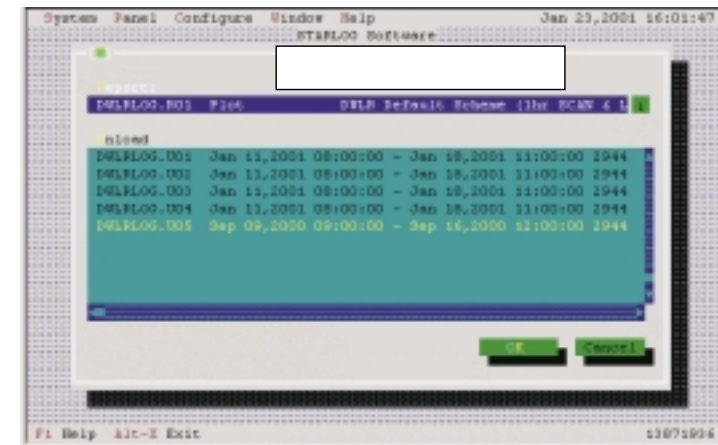
UNIDATA PDL Compiler Version 1.19
[Redacted]
Unloading DWLELOG
Scan for Prompt... OK
Check scheme... OK
Unloading Data to 'C:\STARLOG\SCHEMES\DWLELOG.004' (282 bytes)
[Redacted]
OK
Unload of 282 bytes complete, no errors detected
  
```

The optional unload method is to select Incremental Unload from the Scheme Menu. This will save a U file of the data recorded since the last time data was unloaded. This is typically used at sites operated by telemetry to reduce communication costs.

6.2.2.2 Reviewing the Unloaded Data - Displaying an Unload File

The Unload files are binary files of unscaled data. The Scheme contains the reference information needed to scale and format the data as plots, or the files and listings required for further analysis. Reports are used to define how the Scheme data is presented. You can create and edit reports from the Scheme Menu. These reports may then be selected when you review the recorded data.

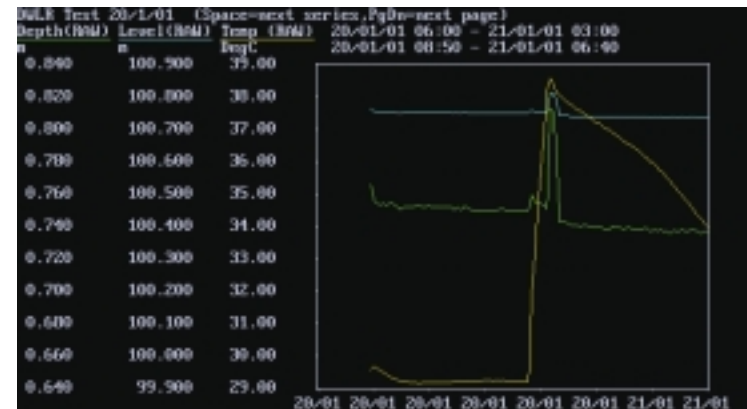
Select Display an Unload File from the Scheme menu. The following screen allows you to select from the range of Reports that you have created, and files you have unloaded.



A typical Scheme should have at least a Plot report for data review at the site, and an ASCII report to save a data file for later processing. A Screen Listing report can be useful to examine each data point in details.

6.2.2.3 Reviewing Plots

Select a Plot report, and the Unload file of interest. The plot will be displayed, as defined in your report. You can expand and contract axes, and add and remove variables. See the Starlog V3 Software manual for details.



Review the Plot of the data from each Transducer shown. Look for any unusual data shapes or ranges that may indicate a problem. When you have finished, press the PgDn key to return to the Scheme menu.

6.2.2.4 Reviewing a Screen Listing

A screen listing may be used to detail each recorded data point. You can move down through the complete listing of the data defined in the Report. The listing may be many pages long. Press Ctrl+Break to escape.

6.2.2.5 To Save the Data for Processing

An ASCII file or Lotus file can be created and used with a spreadsheet to further analyse the data.

Select the ASCII report. A file will be created and saved in the Starlog\Schemes folder as filename *.A##. This is a flat ASCII file suited for spreadsheets and many data processing systems.

6.2.2.6 To Backup the Data

The only copy of the unloaded data, and the ASCII file for processing, is on your computer. It is recommended that a copy of the latest ASCII file be left at the field site on a 3.5" disk. If an accident occurs to the computer or data before it is archived, another copy exists at the field site and can be recovered at the next site visit.

6.2.2.7 Carrying Out Tests And Maintenance

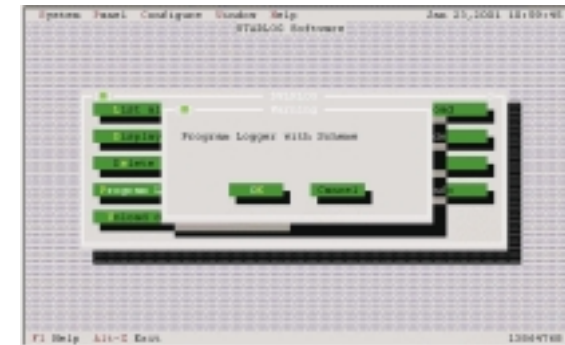
Your data has been recovered and secured. You can now carry out any checks, tests and maintenance required. If the recorded level does not agree with your check remove, inspect, test, clean and reinstall the instrument. See the section entitled *Maintenance* on page 61 for further information.

Your test data will be logged, however it will be erased when you reset the logger before you leave. Note on your visit report details of work you have done and maintenance required at the next visit.

6.2.2.8 Reset the Logger

The logger is normally reset after a routine site inspection and data recovery. It must be reset if the memory will not last until the next scheduled visit, or if the logger power has been disrupted. The reset erases all previous data, reloads the operating software and restarts logging. The data unloaded before the reset must be processed and archived.

If the logger is not reset after a site inspection, it will continue to record data until the memory is full. The next time the logger is unloaded the file will contain all the old data plus the latest period.



The Scheme will be loaded and logging will commence automatically. Logging will continue uninterrupted and you can review, unload and display the data as often as required. Logging will only stop the next time you select Program Logger with Scheme at which time the logger is reset and all old data is lost.

6.2.2.9 Final Site Check

Use Scheme Test Mode to confirm the logging is underway and the time and values are correct. Note this information on your visit report. Disconnect the computer and pack away your equipment.

Take a final look at the instruments and site. Confirm that all is clean, secure and in good condition, with sufficient battery power and logger memory to last well beyond the next scheduled visit. Close up the instrument cabinet and secure the site. Pick up any rubbish and tidy the area.

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7 DATA PROCESSING

This is an essential but sometimes overlooked part of the site operation. Valuable recorded data and background information may be lost or misplaced unless a data processing system is established, documented and used routinely after each site visit. A complete and documented data history is typically kept on a data processing file for the site.

Some sites are operated for many years, and ownership and operators may change. Computer systems and information storage technologies change regularly. Data can be misplaced when such transitions occur.

Adequate time, staff and resources must be allocated to data management to ensure that the original data collection investment returns full benefit.

7.1 Processing System

The appropriate system will depend on the project and the reporting requirements. It is possible to manage data from a small number of sites as spreadsheets, provided the system is well organised and managed. Larger networks require specialised systems and support.

7.2 Securing Original Data

After the data has been recovered from a site the only copy of the data is the file on your portable computer hard drive. This is why the backup copy has been left at the field site. The data file from your portable computer should be archived in the processing system as a protected or read-only file. This should be done immediately you return from the site visit. The processing system computer should be regularly backed up.

7.3 Editing and Adjusting Data

This original file may contain anomalies that have to be edited out, or periods of lost or faulty data caused by site damage or instrument malfunctions. Changes and adjustments are made to a copy of the data (never the original) and comments about what data was changed and why, should be appended.

Changes are normally based on site observations and checks carried out at the site inspections. The site operator should carry out, or be involved in any data editing. This edited data should then be appended to a complete and continuous archive file of all data from the station.

7.4 Reviewing Data

When the latest data has been appended it should form a logical extension of the previous file. Review a plot of all data. The data should be varying continuously and seasonal trends and variations should be evident. A sudden step or offset may indicate an incorrect datum adjustment, or a change in the instrument position. Flat horizontal periods may indicate the water level is below or above the instrument range.

If apparent data problems are identified a note should be added to the station visit file, to remind the site operator to attend to the matter at the next site visit.

8 MAINTENANCE

The WDP instrument is designed to require the minimum possible amount of maintenance. The internal battery will need to be replaced after five years, or sooner if intensive logging or communications have been carried out. Apart from the battery, there are no parts the instrument that can be serviced by the user.

On site the only maintenance required is for the operator to:

- Keep the instrument clean and protected from damage.
- Clean the water inlet ports on the probe lower end if they become blocked.
- Replace the desiccant crystals and make sure the vent tube is not blocked.
- Monitor a history of site checks for calibration changes.

8.1 Instrument Maintenance

Normally the instrument should only be opened by experienced instrument technicians, in a suitable workshop. However it is possible for a battery change to be done at the field site provided great care is taken.

8.1.1 To Replace the Battery

The internal Lithium battery pack should be replaced after five years, or if the voltage displayed is 0.5V. It is recommended that a competent technician in a clean workshop environment should carry out this work.

It is possible to change the battery at a field site, with care. Practice the change in a workshop before attempting it in the field, and ensure you have suitable tools. Cleanliness is essential. The instrument relies on 'O' rings for waterproof sealing. Any dirt or damage to these seals may result in a water leak, and severe instrument damage.

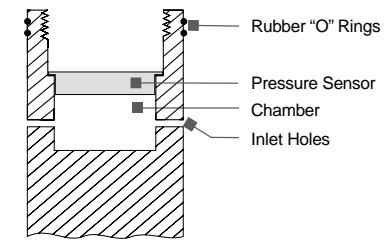
Do the following:

1. Unload and secure any data in the WDP. See the section entitled Site Operations on page 49 for details. All data will be lost when the battery is removed.
2. Wash and dry the probe so that there is no dirt or water to contaminate the interior.
3. Remove the 3 screws on the sensor end of the probe. Twist gently to separate the sensor from the body. The sensor is plugged into the circuit board. Unplug it, noting the alignment. Set the sensor assembly to one side.
4. Remove the 3 screws on the cable end cap of the probe. Carefully slide out the electronics and battery assembly. Take care not to touch the circuit board onto the metal housing. Set the housing to one side.
5. Unplug the battery connector. Unclip it and push it out with a small screwdriver from the circuit board side.
6. Remove the board mounting nuts from the three mounting rods that form the battery guide. Unplug the circuit board and set it to one side.

7. Note the position of the wires at the back of the pack. Cut the tape and remove the old battery pack. Mark it as used and with the date of removal. Recycle the pack for reconditioning. Install a new pack and tape it into position. Mark the installation date and voltage on the pack.
8. Mount and reconnect the circuit card. Tighten the nuts. Check the circuit board and the battery rack are in alignment. Plug in the new battery assembly.
9. Wipe the inside of each end of the body, to clean the O ring seats. Carefully slide the body over the circuit card.
10. Clean then lightly lubricate the 'O' rings on the cable end cap with silicon grease. Reassemble the cable end cap taking care not to nick the 'O' ring on the probe housing. Replace the 3 screws.
11. Clean then lightly lubricate the 'O' rings on the sensor end cap with silicon grease. Reconnect the sensor. Reassemble the sensor end cap taking care not to nick the 'O' ring on the probe housing. Replace the 3 screws.
12. Connect the WDP to your computer. Select a test Scheme and program and test the logger. Check the readings in and out of water. Log a period of data, then unload and review the data. Confirm that all is OK prior to re-deployment.
13. Recondition the old lithium battery pack. Solder new cells in position. Recycle the old cells, or return them to the manufacturer or supplier.

8.2 Cleaning the Water Inlet Ports

The pressure sensor is located just above the four inlet holes near the bottom of the instrument. These holes lead to the small chamber where the pressure sensor is mounted. The holes are aligned 0.5mm below the delicate face of the pressure sensor. If the holes are blocked the correct water pressure will not reach the sensor. If the chamber fills with silt or sand, biological growth or chemical contaminants, this may apply pressure to the sensor and result in incorrect depth measurements.



Section of pressure sensor chamber.

The inlet holes should be inspected regularly and kept clean. You can not see the sensor. Check and note the zero reading of the instrument, in air see the section entitled *Calibration* on page 67 for details. An offset may indicate the sensor is dirty or fouled. Recheck the offset after cleaning. Note all results as these may be required to adjust the data during processing.

If these water inlet ports are blocked with silt or sand, wash all the material from the holes and sensor chamber using gentle water pressure. For dry silt, or chemical or biological deposits, soak in a suitable mild solvent to soften the material before cleaning.

When cleaning the ports avoid using sharp objects and touching or distorting the sensor. For very persistent blockages use a 5.0mm drill bit to clean each port by hand. Flush the ports and chamber with clean water after cleaning. Blow the sensor dry. Check and record the zero reading prior to deployment.

8.2.1 Servicing the Desiccant System

An atmospheric pressure vent tube is part of the cable. As the temperature changes at the site, air breathes in and out through this tube. Any obstruction such as a drop of water, or a small insect can block the tube and cause significant errors in the recorded depth. The UNIDATA Model 6603DT desiccator plugs onto the end of the tube to filter and dry any air entering the tube.

The desiccator assembly contains a filter pad, standard colour-indicating silica gel crystals and a breather cap. The assembly can be exchanged, or reconditioned on site. The crystals are blue when dry and turn pink as they absorb moisture. When crystals start to turn pink the desiccator is no longer effective.

To recondition the assembly, remove the cap and pour the old crystals into a storage container. Refill the desiccant container with dry silica gel crystals. Replace the cap leaving it unscrewed ½ turn to allow it to breathe. When the cap is closed the vent tube is blocked and large water depth errors may be recorded.

The used silica gel can be reconditioned many times by heating in an oven for 1 hour at 100°C or in a microwave on low, until the crystals turn blue. Place them in an airtight container to cool. Store them in airtight containers to avoid moisture absorption.

8.3 Site Maintenance

8.3.1 Overview

All sites and instruments need regular maintenance. The instrument systems need a secure location, a reliable power supply and protection from interference and damage. The site also requires maintenance. The instrument can work well, yet record poor data if the sensor moves or is blocked, or the water level at the sensor is incorrect.

8.3.2 Regular Maintenance

At each site inspection your routine checks should detect any problems that are affecting the data, and these should be fixed. Keep all sites tidy and in good condition. Trim vegetation, maintain and paint structures and clean instrument cabinets. Check for accumulations of silt that may bury the instrument.

8.3.3 Annual Maintenance

An annual check of the site conditions should allow additional time to carry out a thorough check to detect and fix any changes or deterioration that may affect the site data in the future. Take the time to review the data from the past year. Look for trends that may indicate changes to the instrument calibration, sensor contamination or the stability of the instrument position.

It may be desirable to modify the instrument location or change the way it is installed or housed, to prevent future problems.

9 CALIBRATION

9.1 Overview

The WDP is an extremely accurate instrument, using a precision sensor and state-of-the-art electronics and software techniques. This section describes the factors affecting the accuracy of all pressure transducers, and the calibration techniques that can be used to manage them.

At manufacture each WDP is calibrated to an accuracy of less than $\pm 0.05\%$ of full scale for the full pressure range and for the temperature range 0 to 50°C. Complex measurements define and remove the imperfections from individual sensors and circuits. The derived equations for Depth and Temperature are saved in EEPROM within the WDP. They can be viewed using the CDT editor.

UNIDATA provides a printed copy of the calibration equations and a calibration certificate with each instrument. You will need this listing to restore the original calibration if the EEPROM values are lost.

In effect all points are mathematically adjusted to lie in a straight line, between zero and full scale. However all pressure sensors are piezo-resistive devices and their characteristics may change with temperature, age, stress and contamination. These changes may affect the calibration. During transport, testing and installation some instruments may experience pressure and temperature extremes, and accidental knocks and bumps. In use, biological growth or mineral deposition may change the sensor outer membrane. These changes may effect the calibration.

UNIDATA provides tools that allow you to reset the zero and adjust the calibration to remove errors.

The specific gravity of natural water changes by more than 3%. This is a major potential source of errors in depth measurements.

UNIDATA has calibrated each WDP using a specific gravity suited for fresh water at 25°C. This specific gravity may be changed to suit your site, using the CDT editor provided.

9.2 Accuracy Expectations

Most pressure instruments use a piezo-resistive sensor. These sensors are supplied by a small number of manufacturers, who test each sensor and sort them into accuracy grades. Even the best grades still do not have the accuracy required for precision water level monitoring. The design and calibration of the WDP during manufacture, improves the accuracy to the required standard.

Pressure transducers are easy to install and use. However the accuracy of data may change with time. Understanding these limitations and how to detect and manage them will improve the quality of the data you collect.

The specified accuracy of a 0-20m instrument is $\pm 0.1\%$ of full scale, $\pm 20\text{mm}$. It is not suited for high precision or extremely accurate monitoring.

- It is not possible to measure water level to an absolute accuracy of (say) $\pm 3\text{mm}$, year after year, with this type of pressure transducer. The specified accuracy of a 20m instrument is $\pm 20\text{mm}$.
- It is not possible to accurately monitor a depth of 50mm with an instrument with a full scale range of 20 metres.

You would need to use a float operated instrument such as the UNIDATA Model 6541, to achieve such high precision and accuracy.

Changes occur slowly within a pressure transducer: the calibration is said to “drift”. The relative accuracy is good: the difference between a level today and tomorrow will be accurately measured. The absolute accuracy may not be as good: a level measured today may be different from the same level measured one year ago.

The changes experienced within a pressure transducer are small, erratic and unpredictable. Manufacturers specify the instrument accuracy as an error range, or band, based on tests, statistics and experience. The specifications quote the worst expected case and the majority of instruments will be much better than this.

9.3 Interpreting Accuracy Specifications

The accuracy of the WDP is specified as $\pm 0.1\%$ of FS (Full Scale). As an example, this means that for a 20m range WDP, the reading at any depth in the range (including zero) will be within $\pm 20\text{mm}$ at a temperature of 25°C . In fact all instruments are within $\pm 0.05\%$ at the completion of calibration. The quoted specification allows for some changes that will occur before you install and commission it.

The instrument calibration may change with time, as electronic components age, materials change and environmental effects accumulate on the sensor. The aging change is specified as $\pm 0.1\%$ of full scale/year. This means that 12 months after manufacture the calibration may have changed by a further $\pm 0.1\%$ of FS.

The calibration process defines and removes most thermal effects, however aging can also change this relationship. The recorded water depth may exhibit a diurnal change as the pressure sensor responds to water temperature changes.

If you are lucky the various errors will cancel each other out. If you are not, the errors will compound. The worst probable error can be calculated by adding together the maximum of all possible errors. Careful site operation or controlled tests can monitor all calibration changes. This information can be used to adjust the data as it is processed, and to correct most effects.

In natural waters the pressure instrument may be exposed to site or water conditions that can cause errors much larger than those related to the sensor calibration. For example, the specific gravity of the water changes with temperature and can introduce seasonal and diurnal variations of up to 0.5% of the depth. Salinity changes the specific gravity of water by 3% between fresh and seawater. In open channels the velocity of water flowing past the sensor holes can cause depth “offsets” that can be very large if the water velocity is high. The maximum effect (metres) is $= \text{Velocity}^2 (\text{m/sec}) / 19.6$. These errors can be minimised by astute site design and operation.

9.4 Calibration Options

9.4.1 Overview

The WDP will not normally require any re-calibration. Regular site checks carried out for quality assurance purposes will usually include comparisons of the actual and recorded water levels. If consistent minor differences are recorded, the WDP calibration may be checked and adjusted to reduce or eliminate them. If major and erratic differences are recorded that are not caused by site conditions, the WDP should be returned to the manufacturer for service and re calibration.

9.4.2 Adjusting the CDT Editor Settings

The CDT editor contains the basic firmware settings used to calculate the depth before the transducer scaling is applied. You use this option to:

- Reset the WDP zero to remove a zero error when this is confirmed by your zero checks.
- Adjust the SG of water to “tune” the instrument to the average water quality at the site.

CDT changes are saved in the WDP EEPROM and “permanently” change the instrument settings. They will be used with any Scheme loaded into this instrument. All data must be recovered and secured before changing the CDT.

9.4.3 Adjusting the Site Scheme

The site Scheme contains the scaling factors to be used to calculate the Depth and Level displayed at the site and presented as plots and listings. These factors are saved in the Scheme but not permanently loaded to the WDP. They are used to scale the data from any Unload file that you process.

If you wish you can:

- Enter the new a: and b: values into Scheme Editor | Instrument Panel | Transducers | Depth.
- Enter the same a: value into Scheme Editor | Instrument Panel | Transducers | Level.
- Enter the same b: value plus any level datum adjustment to Scheme Editor | Instrument Panel | Transducers | Level.

Save the Scheme. You do not need to use Program the Logger with Scheme. Select Scheme Test Mode to see the results. Plot or list any Unload file to produce data using the new scaling.

9.4.4 Complete Recalibration

This can only be carried out by the manufacturer. This process results in the errors associated with non-linearity, hysteresis and thermal effects being mathematically removed, and new Zero and Full Scale values being derived. New EEPROM values will be derived and entered.

9.5 Calibration Checks

During your site checks you will compare the displayed water level with an accurate check water level. At some sites you may lift the instrument out of the water and obtain a zero check. When a series of these checks are recorded and plotted, any calibration errors and trends will become apparent.

Errors attributed to site conditions, such as the sensor being buried, contaminated by chemical deposits or biological growth are not calibration changes. Nor are transient water specific gravity changes or water velocity effects.

If the site checks indicate a possible calibration change, a series of simple tests can be carried out to check the present calibration.

9.5.1 Zero Check

The most common change occurs in the instrument zero. When the instrument is out of water it should display a Depth reading of zero. If not, there is an offset that will apply to all data. The instrument zero is extremely sensitive. A drop of water on the sensor can cause a 10mm offset, and there can be several millimetres differences between the reading with the instrument vertical and horizontal position. A blocked vent tube can cause a large offset. It is important to take care to obtain an accurate and valid zero check. The following technique is recommended.

Recover, review and secure any data from the WDP as subsequent checks will permanently change your data logger. Reset the transducer scaling for the Depth and Water Level transducers back to the default values, removing any previous adjustments. The site datum adjustment entered as b: in the Water Level Transducer panel, as this will have to be re-entered at the end of the check.

Then:

1. Open your Scheme | Instruments | Transducer.
2. Reset both the Depth and Level to default values (a: 0.001, b: 0).
3. Save the Scheme.

Then do the following:

1. Remove and clean the WDP and wash out the sensor ports and sensor chamber.
2. Dry the WDP and hang it vertically for at least five minutes.
3. Check the desiccant holder cap is open, to allow the vent tube to breathe freely.
4. Connect your computer and open the Starlog V3 software. Load the Scheme with default values for a: (0.001) and b: (0).
5. Select the Scheme Test Mode screen. Note the depth reading. This is the present zero offset.

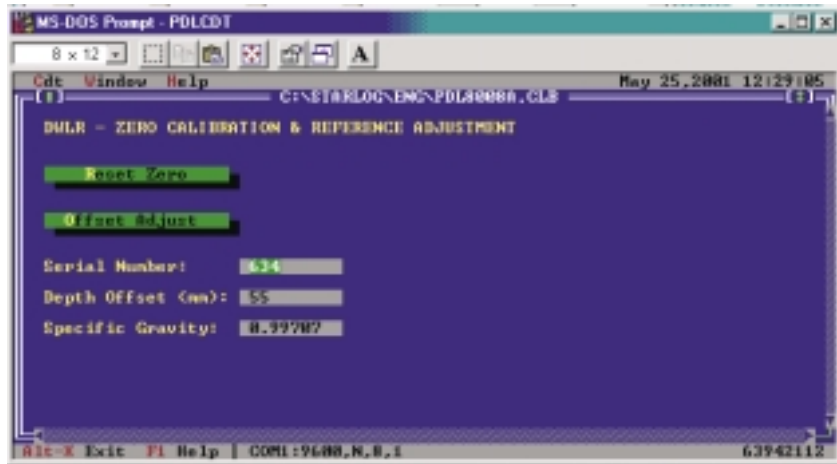
To check that the offset is stable, disturb the reading and check that it returns to the same display:

1. Gently tap the WDP with your knuckle, and see if the offset changes.
2. Suck on the vent tube. This will cause the “depth” to increase, then settle back. Note this reading.
3. Blow on the vent tube. This will cause the “depth” to fall, then settle back. Note this reading.

All readings should be the same, within ± 3 mm. This is the offset.

9.5.2 Using the CDT Editor to Reset Zero

Select System and CDT Editor from the Menu Bar of the opening screen. Select OK to upload the CDT editor from the WDP. The following screen will be displayed.



Select CDT Editor again, and Download CDT to adjust the WDP. Select your Scheme then select Program Logger with Scheme. Open the Scheme Test Mode screen. The instrument should now display zero when suspended in air.

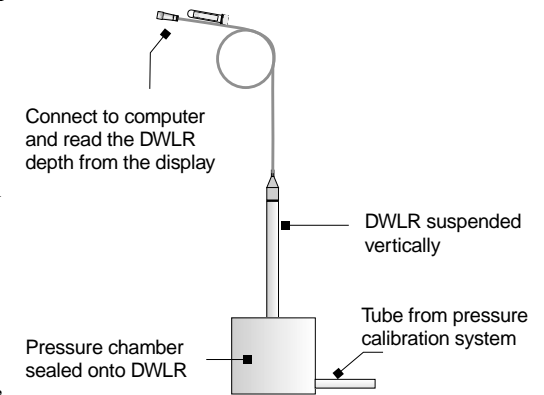
9.5.3 Slope Check

This test is to check how accurately the instrument measures known depths, or pressures. If all depths are recording (say) 2% low, increasing the calibration slope by 2% will correct the data as it is reported. This can be done by adjusting the a: factor in the Scale equation for the Depth and Level instruments, in the Scheme Editor. The default value for a: is 0.001.

First complete the Zero Check described in the previous section (including unloading and securing your data). Reset the instrument zero before proceeding with the slope check.

9.5.4 Using a Pressure Test System

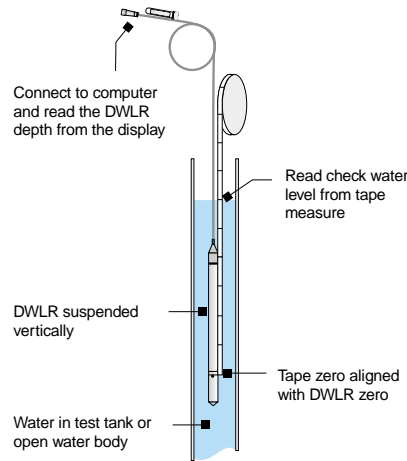
If you have access to a pressure calibration system you will need a small chamber that can seal over the end of the WDP. You can then generate a series of known pressures from zero to full scale and down again, in steps of about 20% of the range. Record the pressure and the displayed depth. The test pressure will need to be converted to a water depth, using the same water specific gravity as used for the WDP.



9.5.5 Using a Water Column

The WDP depth can also be checked by submerging it into a known depth of water. For instance in exactly 1m of fresh water at 25°C, the WDP should read 1.000 m ($\pm 0.1\%$ FS).

The transducer zero is marked by an engraved line just above the sensor vent holes. All depth measurements originate from this point.



To check the depth:

1. Attach an accurate measuring tape to the WDP, with the tape zero exactly lined up with the engraved instrument zero.
2. Lower the instrument into water and accurately read the depth from the measuring tape. Compare it with the recorded depth displayed in the Scheme Test Mode screen.
3. If you have a suitable test site, take readings over as much as the WDP range as possible, ideally through the full range at increments of about 20%, both increasing and decreasing. Record all sets of checks.

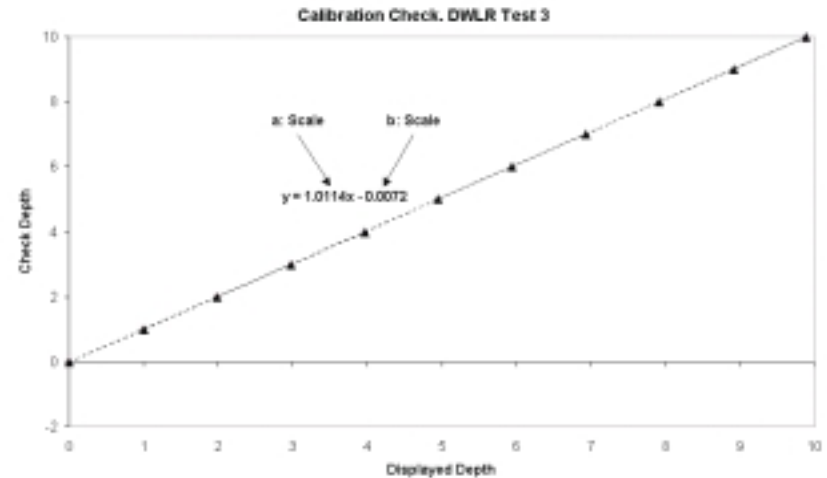
9.5.6 Calculating the Correction Factor (using Excel)

To determine the calibration Scale factors, plot the data and establish a linear regression through the points.

The following example uses Excel Version 97. Other worksheets have similar features.

1. List your data in a Spreadsheet with the displayed depth in A and the check depth in B.
2. Start the Chart Wizard and Select Plot type XY (scatter). Highlight the data, which will be plotted.

3. Click on the data points on the graph. Select Graph | Add Trendline. In the window select Regression Type Linear. Open the Options panel and select Display equation on chart.



4. Enter the displayed values as the new a: and b: values to the Scheme Editor | Instrument Panel | Transducers | Depth and Level.
5. Save the Scheme and then select Program Logger with Scheme.
6. Select Scheme Test Mode, and then test the WDP in a range of depths. Confirm that the displayed data is accurate. The new scaling will now adjust any Unload file by the specified amount.

Display	Check
0	0
0.998	1.000
1.988	2.000
2.973	3.000
3.966	4.000
4.952	5.000
5.94	6.000
6.927	7.000
7.914	8.000
8.912	9.000
9.889	10.000

9.6 Specific Gravity

The default specific gravity used in the WDP is 0.99707. This value is suitable for fresh water at 25°C. The following table indicates some of the SG variations encountered in the typical range of natural water. To minimise errors in the computed depth, select an SG that represents the median water condition at your site.

Temperature °C	SG "fresh water"	SG "sea water" 35g/l
0	0.99987	1.0281
4	1.0000	1.0277
8	0.99987	1.0273
12	0.99953	1.0264
16	0.99897	1.0257
20	0.99823	1.0248
24	0.99732	1.0234
25	0.99707	1.0234
28	0.99626	1.0224
32	0.99505	1.0211
36	0.99371	-
40	0.99225	-

Enter the SG you select into the WDP using the CDT editor as in the following example. The instrument will be permanently changed until the next time the SG value is edited.

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Appendix A - Model 8007 – WDP Notes

A - 1 Long Scan Rate

Unlike all previous STARLOGGER and 8007 MicroLogger products, the Model 8007WDP has extended scan rate settings.

The scan rate for this model may be set from 5 seconds up to 6 hours. The WDP has a ½ second timebase rather than the standard 1/128 second found in other loggers.

The slower timebase and the extended scan rate have a very significant impact on the power used by the instrument. This has enabled the WDP to be operated from an internal Lithium battery for up to five years.

A - 2 Battery Life Calculations

The Model 8007 WDP is supplied with an internal lithium battery. The capacity of this battery is 7.2Ahr with a shelf life exceeding ten years (reduction of capacity by 20%). The standby (continuous) current drain by the WDP is less than 30 microamps, and the operational current is less than 50 milliamps. A measurement (scan) takes 750 milliseconds (3/4 second) at the 50mA level. Communication with a computer/modem also occurs at the 50 milliamp rate.

By extending the scan rate as long as possible (one hour or greater) the power consumed by the measurement process becomes less significant and the battery life becomes determined by the continuous standby current (30µA).

A - 2.1 Power Consumption and RS232 Communications

Another potential source of significant power drain is RS-232 communication with the WDP. During communications, the WDP remains permanently on (consuming 50mA). Therefore, it is absolutely imperative that continuous communications with the WDP be avoided. Normal communications during Scheme Loading, Data Unloading and Test Mode interrogation *do not* impact battery life, but third part (non-V3) interrogation must be structured so as to limit the impact on the battery life.

The following calculations give insight to battery life calculations:

Parameter	Units - Ah/year
Standby Power	0.26
Battery Aging	0.14
WDP Scan & Log	0.10*
Interrogation	0.02**
0.52 Ah pa	

* One hour scan rate

** Based on monthly data unload and test mode interrogations

Conclusion: Based on a scan rate of one hour, the battery energy used is 0.52Ah, so with 7.2Ah available, the conservative operational battery life expectancy is more than five years.

In contrast to this excellent battery duration, the following operating methods will significantly reduce battery life:

- Continuous communication reduces the battery life to five days.
- A five second scan rate reduces the battery life to one month.
- A one minute scan rate reduces the battery life to one year.

WARNING: The WDP should never be operated at scan rates of less than 10 minutes.

A - 3 Version 3 Software Update

You must use Ver3.09 Rev E of the STARLOG software with the WDP.

To enable the V3 to support the long scan rates used in the WDP, several system files have been modified. Default files PDL8008* are used in Scheme Generation, while *.CCF files modify the way V3 will communicate with the WDP. The PDLSCHEM.SRC file has been modified for Log Program operation.

To maintain compatibility with Version 3 software, the WDP has been defined in the software as having a ONE (1) SECOND scan rate. This enables V3 to synchronise the WDP's Time-of-Day to within one second resolution (rather than to within one scan/hour).

The Log Program will also be ready to start logging at the next scan (which could be up to one hour away). The first log recording will be at the next Log Interval after the WDP is programmed (which may also be at the next scan).

Scan Rates may be selected from 5 seconds to 6 hours. Scan rates faster than ten (10) minutes, must only be used for test purposes when external power is connected. The recommended Scan Rate is one (1) hour.

The Log Interval can be of one or more Scan Rates duration, but cannot be more than 18 hours. Therefore, you cannot generate a Scheme that logs only once per day (24 hour Log Interval), you must specify a 12 hour Log Interval and record twice a day). Averaging and Max/Min are supported as expected.

Test Mode operates as expected, but does not continuously refresh the screen with live data. On entry to Test Mode, one interrogation sequence occurs and the screen is updated with realtime measurements and log entries, then the WDP is powered OFF (to conserve the battery). To examine another live reading, you must exit Test Mode (Alt+X) and re-enter from the Scheme menu.

CDT Editor This utility also works as expected, with one minor variation. On entering the CDT Editor, you will be prompted to continue or cancel. If you do not respond to this prompt within ten seconds, the WDP will have switched OFF and the CDT screen will not be displayed. To overcome this inelegancy, simply press the Enter key as soon as you have selected the CDT Editor (ie. Alt+S, C Enter).

WDP Hardware and Firmware - The major alteration to the operation of the WDP is to support long scan rates, so that the battery life can be extended.

The WDP supports a mode of operation which is slightly different to other UNIDATA loggers; the Time-of-Day is counted in seconds, rather than the programmed Scan Rate intervals.

To achieve this, the WDP "tells" the V3 Software that it has a 1 sec Scan Rate (irrespective of the actual Scan Rate) and the V3 system will set the time into address 4 of the WDP (at Scheme loading time) in seconds past 1980. During the Initialisation command that follows Scheme loading, the WDP uses the time in address 4 to calculate how long until the next "real" scan interval as defined in the Scheme (typically 1 hour) and initialises the hardware accordingly.

For example, if the WDP is programmed at 1044 with a 1 hour Scan Rate, the first measurement will occur at 1100, the next at 1200, 1300 etc.

Whenever the WDP is powered ON (due to a scan or a computer interrogation) it will update address 4 with the correct number of seconds past 1980, to simulate a one (1) second scan rate for V3 compatibility. This means that if you enter Test Mode, the NOW TIME display is the real time in seconds.

If you generate a Scheme using software other than V3, you must remember to synchronise the WDP time to seconds past 1980 (using the (P)ut command into address 4) followed immediately by the (I)nitialise command.

A - 4 WDP Battery Replacement

This procedure can be carried out in the field, but requires care and cleanliness. Do the following:

- 1 Unscrew the three front retaining screws, then remove the pressure sensor fitting disconnecting it from PCB.
- 2 Unscrew the three rear retaining screws and remove the main tube.
- 3 Disconnect the battery plug.
- 4 Unscrew the three nuts securing the PCB holder to the cable end fitting and withdraw the holder and PCB from the threaded rods.
- 5 Unwrap the tape securing the battery pack to the threaded rods and withdraw it.
- 6 Replace battery, PCB holder, battery plug etc. in reverse order of disassembly.

WARNING: Inspect ALL O-RINGS for any damage and replace if necessary.

NOTE: It is recommended that battery replacement is performed in a workshop where the instrument can be thoroughly examined and re-calibrated. As this procedure need only take place once every five years, it should form part of a regular workshop inspection maintenance procedure.

Calibration Coefficients The calibration of the WDP is defined by a unique set of calibration coefficients.

There are two sets of coefficients; one set for the Pressure/Depth calibration and the other for the Temperature calibration. These coefficients are held in EEPROM inside the WDP and also printed on the calibration and configuration listing, titled PDL8008.CDM, that accompanies each unit. These coefficients can only be determined by an extensive factory calibration process, so please keep this listing secure.

Field Calibration It is possible to perform a second level of linear calibration. This involves performing a zero and full-scale adjustment using the optional V3 calibration software extension.

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Appendix B - COMPUTER COMMUNICATION

The WDP contains a MicroLogger which is similar in operation to other UNIDATA Data Loggers.

This section describes the detailed operation of this Data Logger. Most users will not need to refer to this information. The Model 8007WDP Support Software provides all the necessary communication and programming requirements in an easy-to-use package (see section 5).

B - 1 COMMUNICATIONS (STARLOG) PROTOCOL

The WDP communicates using standard asynchronous, RS-232 serial communication standards which allow it to communicate with an IBM PC or compatible computer.

The communication format is:

- RS-232C compatible.
- 300 to 76800 baud (9600 baud default).
- 8 data bits, 1 stop/start bit, no parity.

You connect a computer to the WDP via the 9-pin socket which is part of the Model 6603D cable. This allows you to load and unload schemes and data.

If the interface is connected, the WDP sends a prompt to the interface (host computer). This prompt is an ASCII asterisk followed by a carriage return (*c/r).

The WDP then waits 1 second for a request from the host computer. If no request is received the WDP powers down (switches off).

If a scan occurs during RS-232 communications then the measurement and reading will be processed.

B - 1.1 Data Logger Requests

The following are valid Data Logger requests (or Commands). If the logger receives an invalid command it will be ignored. Other commands are used to maintain and initialise the Configuration Table (see Appendix D).

A WDP has three basic commands - GET, PUT & KILL. The (G)ET and (P)UT commands will access the first 64K of memory only. For memory sizes greater than 64K, a lowercase equivalent of the basic commands serves as an Extended Protocol Command (i.e., “g” command performs an extended “G” GET command). All Extended Protocol Commands require a checksum following the message.

See the STARLOG Programmers Supplement (6201) for a complete list of STARLOG Protocol commands.

■ GET {and (g)et} Commands

GAAAASS where G is the GET command, AAAA is the 16 bit address (MSB/LSB) and SS is the number of bytes required. (Zero in the SS command corresponds to 256 bytes.) (AAAA is the command for a 16 bit address in the first 64K memory storage of the Logger.)

Gaaaaaaaasssscccc

Where g is the get command, aaaaaaaa is the 32 bit start memory address (MSB...LSB), ssss is the 16 bit number of bytes to transfer, and cccc is the 16 bit checksum.

To read 256 bytes from address 768 into the host computer the command is:

G030000

The same command using the Extended Protocol is:

g0000030001000004

■ PUT {and (p)ut} Commands

PAAAASS

paaaaaaaassss...put data...cccc similar to the GET command except that data is sent to the logger immediately following the command string.

cccc the 16 bit checksum for the (p)ut command includes the address, size and data fields (i.e., everything except the “p” command and the checksum itself) and is sent MSB/LSB.

To reset the logger timer to zero, you will want to put zero into addresses 4,5,6 & 7. The command is:

P00040400000000

P is the put command
 0004 is the offset address (in the registers)
 04 is the put data count
 00000000 is the data to put

To reset the logger timer to 00112233 the Extended Protocol command is:

```
p00000004000400112233006E
```

006E is the checksum

The data format for the GET or PUT is a continuous string of hex characters. The 1st two characters correspond to the 1st byte requested or to be sent, the next two characters is the second byte, etc. The data string is terminated by a carriage return.

A command to retrieve 16 bytes may appear as:

```
G000010
```

the returned data may appear as:

```
00112233445566778899AABBCCDDEEFFmmlc/r
```

Where mmlc = Get Data checksum consisting of a 16 bit binary addition of all binary data (not HEX representation) within the retrieved information (excluding the checksum and c/r). The checksum is sent as four HEX characters; mm = Most Significant Byte and ll = Least Significant Byte.

If the checksum overflows 16 bits, then it wraps back to zero. For example: if the intermediate checksum was FFFF and the next data byte was 02, then the new checksum would be 0001.

This is the calculation for the checksum (006E) in the above example of the Extended Put command:

$$00 + 00 + 00 + 04 + 00 + 04 + 00 + 11 + 22 + 33 = 006E$$

Two hex characters are always received or transmitted (most significant digit then least significant digit) even though the number is smaller than 16. E.g., 10 decimal is sent or received as 0A.

GET or PUT may address any continuous segment of the memory.

■ (K)ILL command

K is the KILL command which directs the Data Logger to switch OFF until the next scan cycle (usually 5 seconds).

A command to load location 2 with 0 then exit, would be:

```
P00020100K
```

After a GET command, the computer must wait until the Data Logger has sent the GET data before a KILL is issued.

B - 1.2 SAMPLE PROGRAM

The following program written in Microsoft QBASIC communicates between the Data Logger and an IBM PC or compatible computer.

B - 1.2.1 Simple Interrogation Example

This sample program will issue a command to the Data Logger and display the response from the logger. The commands must be valid commands (see above).

The "ON ERROR GOTO 140" statement is needed to trap (and ignore via RESUME statement) any I/O errors that may occur as the Data Logger powers up and the RS-232 signals lines change states.

The statement 70, sends the command to the logger. Notice that a "K" command (kill) is appended to the operator request. This shuts the Data Logger down, immediately after the request has been completed (to save logger battery power).

Try entering these commands:

```
G000008 (get 8 bytes from location 0)
```

```
G000502 (get 2 bytes from location 5)
```

```
G010010 (get 16 bytes (10 hex) from location 256 (Block 1, Location 0))
P00020188G000201(put 88 into location 2 and immediately gets the data)
```

The maximum G (get) size is 127 (7F hex). This is limited by BASIC string length maximum of 255 characters.

```

10    REM  STARLOGGER - data transfer example
20    INPUT "Enter data logger command-",A$
      `Get Command from operator
30    IF A$="" THEN END
      `Finish on c/r
40    OPEN "COM1:9600,N,8,1,CS0,DS0,CD0" FOR RANDOM AS
      #1
      `Open RS-232 to logger
50    ON ERROR GOTO 140
      `Trap I/O errors
60    INPUT #1,L$:IF INSTR(L$"*")=0 THEN 60
      `Wait for logger prompt
70    PRINT #1,A$;
      `Send command to logger
80    INPUT #1,L$
      `Get response from logger
90    PRINT #1,"K";
      `Send KILL to save battery
100   ON ERROR GOTO 0
      `Reset error trapping
110   CLOSE #1
      `Close RS-232 file (channel)
120   PRINT "Data Logger Response =";L$ `Print result on
      terminal
130   GOTO 20
      `Go back to beginning
140   RESUME
      `Ignore I/O error

```

B - 1.3 MEMORY LAYOUT

The WDP uses its data CMOS memory for:

- Hardware Registers - Storage of housekeeping registers.
- Logger Program - Storage of user scheme definition.
- Buffer Control Table - Storage of pointers controlling Log Buffer.
- Log Buffer - End of logger program to end of memory for recording measured data..

B - 1.4 HARDWARE REGISTER INFORMATION

The information contained in the header may be viewed in Test Mode or used by programmers wishing to write their own unload and analysis programs. The table below gives a description of each register numbered 0 to 255. For multiple byte registers the convention used is – least significant byte to most significant byte (LSB,MSB).

B - 1.4.1 Model 6526, V4x.09 Memory Assignments

The WDP, operating the standard instruction set, has the following fixed memory assignments in the Hardware Register:

Address	Size	Description
0	1	Software Revision Number (40 onwards)
1	2	Log Program runtime in milliseconds (16 bit integer)
3	1	Error flags (see Appendix A)
4	4	Scan counter (32 bit integer)
8	3	Reserved
11	2	msb of address (bits 8-23) used in LDBLK & MVBLK instructions
13	21	Reserved
24	2	Counter Channel C0
34	1	Arithmetic status register set by ADD, SUB, MUL, DIV instructions.
35	5	Reserved
40	2	Serial number (16 bit integer)
42	8	Reserved
48	—	Reserved for Log Program variables
200	2	Water Depth (in mm)
202	2	Water Temperature (in .01 °C)
204	2	Battery Voltage (in .01V)
256	128	Buffer Control Tables A11 - Signal
384	—	Log Program

B - 1.5 WDP - INSTRUCTIONS

The WDP instrument incorporates a STARLOG compatible MicroLogger which is a data recording unit programmed using a computer. Its program resides in the first part of the logger's main memory (after the Hardware Registers and Buffer Control Table). It is defined by a user and loaded into logger memory from the host computer.

The logger program is executed every logger scan (from 1sec to 5min). The first instruction in the logger program is at Address 384. The Data Logger executes this program until an EXIT instruction is encountered (opcode = 0).

B - 1.5.1 WDP - Operation Sequence

Every scan, the WDP performs the following sequence:

1. Measure depth and temperature and battery and store their values in the Hardware Register area (from Address 200 on).
2. Execute the logger program (until EXIT detected).
3. If an RS-232 connection is sensed, send * c/r prompt to Computer Port and wait for a response.
4. Shut down WDP and await next scan time.

■ WDP - Program Instructions

A logger program starts at Address 384 and consists of one or more instructions. Each instruction is four bytes long (even though some instruction do not use all four bytes). An instruction takes about 0.5 millisecond to interpret and execute.

Typical instructions include:

TIMED GOTO	Timer controlled logging sequences
CONDITIONAL GOTO	Event controlled logging sequences
LOG DATA	Flexible data storage command
(BLOCK) MOVE	Block, Word and Byte move
ACCUMULATE	Block summation for averaging
OUTPUT	Control output sequences
BLOCK CLEAR	Storage initialization
ADDITION	2 & 4 byte operands, 4 byte result
SUBTRACTION	2 & 4 byte operands, 4 byte result
MULTIPLICATION	2 & 4 byte operands, 4 byte result
DIVISION	2 & 4 byte operands, 4 byte result or 2 byte result & remainder
SERIAL INPUT/OUTPUT	Bi-directional Data Bus read/write

For a more detailed description of these instructions and WDP memory structure see the *STARLOG Programmers Supplement 6201*.

Appendix c - TEST DIAGNOSTICS

The WDP has inbuilt diagnostic firmware.

WARNING: Once the diagnostic mode has been selected, information stored in the logger may be lost. Always unload the logger before performing test diagnostic requests and also reload the logger after diagnostics.

c - 1 Using the Diagnostics

The Starlog v3 software has an inbuilt diagnostic function. Use this to determine if the WDP and its components are functioning correctly.

To fun the diagnostic function:

1. Connect the WDP to a computer.
2. Run the STARLOG v3 software on that computer.
3. Select System | Test Mode (Alt+F9) from the main menu.
4. Select Logger | Test Display from the menu in the window that appears.
5. After a moment a diagnostic summary will be presented on screen.

WARNING The battery will be seriously depleted during testing. Diagnostic testing should only be conducted using an external power supply.

WARNING Logger will be left in an uninitialized state and will not scan. The User must reset the logger using the Alt - I command (or reload the logger with a valid Scheme).

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Appendix D - WDP SDI-12 INTERFACE

D - 1 INTRODUCTION

SDI-12 is an industry-originated, serial digital interface bus designed to allow an operator to connect a wide variety of transducers (meteorological, hydrological, water quality, etc.) to a single SDI-12 Data Recorder, such as a STARLOGGER, with a single cable bus. This means that you could, for instance, connect several WDP instruments along with the other SDI-12 sensors to another WDP instrument or a STARLOGGER (or another brand SDI-12 Data Recorder) and not have to worry about combinations of RS-232, parallel analog, BCD, serial analog, RS-422, etc. signal types.

A unique feature of WDP is its ability to operate as an SDI-12 sensor or configure the WDP's MicroLogger to be an SDI-12 Data Recorder.

D - 1.1 Default Settings

address	=	0	
retry	=	10	
# of channels	=	2	Level, Temp.
channel 1 address	=	200	Water Level
channel 2 address	=	202	Water Temp.
ID string	=	011UNIDATA 8008A 9.0 <L/F>	
VERIFY string	=	00000 <L/F>	
START string	=	00002 <L/F>	

D - 1.2 WDP SDI-12 IMPLEMENTATION NOTES

The following technical information describes WDP's implementation of the SDI-12 standard.

D - 1.2.1 SDI-12 Data Recorder Commands

Two Scheme Program instructions are used to control the SDI-12 Recorder operation:

SDIGET which collects measurements from the nominated SDI-12 sensor, and

SDICONV which converts the collected data for use by the Log Program. Measurements may be converted into fixed point Short Integers (for manipulation by the Scheme), Floating Point Numbers (for logging by the Scheme) or an ASCII string.

- Integers are two bytes.
- Floating Point numbers are 4 bytes.
- An ASCII string is zero byte terminated.

D - 1.2.2 Data Recorder Coordination

Once an SDI-12 communication has commenced (SDIGET instruction executed) the SDI-12 Bus is busy and will ignore any subsequent SDIGET commands until the active measurement transfer is complete. The measurements are stored in memory, to be converted by a SDICONV instruction.. Converted measurements (stored on MicroLogger channels) may be further processed by the Scheme program and Logged.

Because most SDI-12 sensors (unlike the WDP Sensor) require considerable time to make their measurements (typically 60 seconds), the WDP Data Recorder remains powered up awaiting a response from the sensor. This mode of operation usually requires the Scheme Program to initiate SDI-12 Measurements (SDIGETs) two scans prior to the desired Log Interval.

The sequencing of the SDI-12 measurements is under the control of the Scheme Program (which is defined using the Scheme Editor).

D - 1.2.3 Measurement Errors

If during a data collection sequence (SDIGET) an error occurs, the sequence is retried a total of ten times (by default). A non-recoverable error causes the SDIGET instruction to report a "null" result and a subsequent SDICONV will not return any data (the channel readings remain unchanged from their last good reading).

D - 1.3 WDP SDI-12 Command Implementation

The following table shows which SDI-12 commands are and are not recognised:

Command	Description	Sensor	Data Recorder
a!	acknowledge	✓	✗
aI!	send identification	✓	✗
aV!	start verification	✓	✗
aM!	start measurement	✓	✓
aD0!	send data	✓	✗
aM1...9!	start additional Measurement	✗	✓
aD1...9!	send additional Data	✗	✗
extended commands		✗	✓

D - 1.4 Transparent Mode (Extended Commands)

WDP supports a transparent mode of operation that allows “ad-hoc” commands from an external computer (or modem) to be sent to SDI-12 Sensors connected to the SDI-12 bus.

This mode is entered using the STARLOG protected command:

```
tssss01
```

Extended commands may be issued whilst the Scheme Program is operating, but remember that the extended commands may disrupt the Scheme Program data collection timing. Type Alt+T from within the Communications window to enter this mode.

D - 1.5 SDI-12 Test

To check the operation of the SDI-12 Recorder the following sequence can be tested:

1. Configure the WDP as SDI-12 Data Recorder and enable SDI-12 operation.
2. At address 384 (Log Program) insert these instructions:

```
128 0 255 4          SDIGET  BUSY
129 1 100 0         SDICONV  INTEGER,100
128 0 0 0          SDIGET  CHAN0
0                               BUSY:  EXIT
```

This sequence will branch to “BUSY” whilst SDI-12 bus is busy – then convert the previous measurement to 16 bit integers stored into addr 100 – then issue a SDI-12 measurement sequence to the Sensor at SDI-12 address 0.