



PROTEUS INSTRUMENTS

Proteus User Manual

V1.3 May 2019



Foreword

The material presented in this instruction manual is intended to help the reader gain an understanding of the operation and maintenance of the Proteus. Proteus Instruments advises all users to read the manual before operating or deploying the instrument.

Suggestion that would improve the clarity of the information presented in this manual or additional information that would enhance the operation of the equipment is welcomed.

Proteus Instruments is committed to improvement of its products and services and thus reserves the right to change instructions, specifications and schematics without notice.

Contact information

Technical support / customer service:

Tel: +44 (0) 1527 882060

Email: info@proteus-instruments.com

Other correspondence:

Proteus Instruments Ltd, Leask House, Hanbury Road, Stoke Prior, Bromsgrove B60 4JZ, United Kingdom

General Warnings:

Before operating or installing this equipment, it is important that all hazards are acknowledged and potential preventive measures are fully understood. Site specific hazards related to location and application type, take heed of the following general warnings:



Tryptophan like fluorometers house an ultraviolet LED. Do not look directly at the UV LED when it's switched on as direct exposure can damage the eyes. This product should be kept away from children, pets and other living organisms. Wear safety goggles when looking at the optical window.

Do not manually force rotate the wiper arm

Pay attention to and respect regulatory and legal requirements regarding the safe handling and disposal of calibration fluids, batteries and all materials you or the Proteus may come into contact with.

Avoid hazardous practices when operating/installing this instrument. If used in any way not specified in this manual protection provided by the instrument may be impaired.

Contents

1	Background.....	1
1.1	What is fluorescence.....	1
1.2	Measuring organic matter using fluorometers.....	2
2	Instrument Specifications.....	4
2.1	Instrument.....	4
2.2	BASIC APPLICATIONS.....	6
2.2.1	Manual Data Collection.....	6
2.2.2	Unattended Logging.....	6
2.2.3	Telemetry Relay.....	6
2.2.4	Online Monitoring.....	6
2.3	Status Indicator Lights.....	7
2.4	Accessories.....	7
3	Communication Software.....	8
3.1	System Requirements.....	8
3.1.1	Control Software.....	8
3.1.2	Serial Adapter Drivers.....	8
3.2	Interface Screen.....	8
3.3	Hot Buttons.....	9
3.4	Drop-Down Menus.....	10
3.4.1	PC menu.....	10
3.4.2	Proteus Menu.....	11
4	Installation.....	15
4.1	Open water installation.....	15
4.1	FLOW CELL Installation.....	16
4.2	Routine Maintenance.....	17
5	Calibration.....	18
5.1	Basics of Parameter Calibrations.....	18
5.2	Choosing Calibration Standards.....	18
5.3	Calibration Record ('Cal Log').....	20
5.4	Sensor Response Factor (SRF).....	20

5.5	Units/Conversion Factors.....	20
5.6	Factory calibration	20
5.7	Turbidity Calibration	21
5.8	Tryptophan Calibration and Compensation.....	23
5.8.1	Typical Ranges	24
5.8.2	Temperature Compensation.....	24
5.8.3	Turbidity Compensation	24
5.8.4	Verification and Calibration	25
5.9	Field Based Calibration.....	25
5.10	Calibration of Other Probes	26
5.10.1	Temperature.....	27
5.10.2	Dissolved Oxygen	27
5.10.3	Conductivity.....	28
5.10.4	pH	28
5.10.5	Reference Electrode	29
5.10.6	ORP	29
5.10.7	Depth and Vented Depth (Gauge).....	30
5.10.8	Fluorometers	30
5.10.9	Ion-Selective Electrodes (ISE's).....	31
5.10.10	Total Dissolved Gas (TDG)	32
5.10.11	PAR (Photosynthetically Active Radiation).....	32
5.10.12	Set Barometric Pressure and Set Time and Date	33
6	Communication and Data Logging.....	35
6.1	Internal Data Logging	35
6.2	Internal & External Battery Packs	35
6.2.1	Batteries and Battery Life	35
6.2.2	Changing IBP Batteries and Activating Logging	35
6.2.3	Logging With an External Battery Pack.....	36
6.3	Direct Connection	38
6.4	Bluetooth	38
6.4.1	Bluetooth Battery	38
6.4.2	Establishing Bluetooth Communication.....	38
6.4.3	Connect to “Classic BBluetooth” Android Data Displays	39

6.5	External Data Loggers and RTU's	39
6.5.1	SDI-12 Adaptor Kit	39
6.5.2	Changing the Proteus SDI-12 AAdapter's Address.....	40
6.5.3	Connecting the SDI-12 Adapter To Your Controller	41
6.5.4	Basic SDI-12 Commands	41
7	Maintenance.....	43
7.1	Turbidity Sensor and Wiper Arm.....	43
7.2	Tryptophan Fluorometer.....	44
8	Appendix.....	45
8.1	Trouble Sshooting:	45
8.1.1	Communication With Ccomputer	45
8.1.2	Measurements values are not realistic:.....	45
8.2	FAQ.....	45
8.2.1	Sensors.....	45
8.2.2	Calibration and Maintenance	46
8.2.3	Communication and Software	49
8.2.4	Deployment and Applications.....	49
8.2.5	SDI-12 commands (version 1.3).....	50

Figures

Figure 1:	Example of quinine sulphate molecules in tonic water emitting blue light when exposed to high energy (UV) light.	1
Figure 2:	Schematic representation of a simple fluorometer design	2
Figure 3:	An Excitation Emission Matrix with the key peaks highlighted	3
Figure 4:	Proteus Equipment Overview	4
Figure 5:	Schematic of Proteus Sensor	4
Figure 6:	Flow Cell.....	7
Figure 7:	Proteus Control Software (PC) Overview.....	9
Figure 8:	Hot Buttons on the Proteus Control Software (PC)	9
Figure 9:	PC Drop Down Menu	10

Figure 10: Proteus Drop Down Menu	11
Figure 11: Calibration Drop Down Menu	13
Figure 12: Custom parameter screen	14
Figure 13: Installation of Proteus in open water with Sensor Guard and support structure	15
Figure 14: installation of Proteus in perforated stilling well for protection	16
Figure 15: Proteus flow cell with barbed connectors.	16
Figure 16: Proteus Instruments default low range relationship (turbidity and temperature corrected tryptophan).....	21
Figure 17: Turbidity Wiper Replacement.....	22
Figure 18: Schematic representation of the calibration procedure for turbidity.....	23
Figure 19: Raw and temperature corrected tryptophan like fluorescence (TLF) of a laboratory standard	24
Figure 20: Change in fluorescence signal with turbidity.....	25
Figure 21: Schematic of Field Based Calibration Procedure	26
Figure 22: Proteus SDI12 Adaptor Kit	40

1 BACKGROUND

The Proteus is a unique, scientifically proven and patented multiparameter sonde that can be loaded with up to 12 physical sensors to measure up to 30 different parameters in real-time including an array of fluorescence sensors that measure:

- Biochemical Oxygen Demand (BOD),
- Chemical Oxygen Demand (COD),
- Total Organic Carbon (TOC),
- Dissolved Organic Carbon (DOC),
- Faecal Coliforms and Total Coliforms.

For a comprehensive list of all the parameters that can be measured by the Proteus please refer to the product specification.

1.1 WHAT IS FLUORESCENCE



Figure 1: Example of quinine sulphate molecules in tonic water emitting blue light when exposed to high energy (UV) light.

Fluorescence is a form of luminescence (i.e. the emission of light not attributed to thermal radiation) that occurs over very short time scales (10^{-9} – 10^{-7} s). The first fluorescent substance to be observed and recorded was *quinine sulphate* (a key ingredient in tonic water). In Figure 1 we can see fluorescence in action –the *quinine sulphate* molecules absorb ultra-violet light (short wave radiation) from the laser pen and then emit blue light (longer wavelength radiation). Molecules that exhibit this property are termed fluorophores.

For fluorescence to be observed and quantified a light emitter and detector is required with some optical components for isolating specific wavelengths of light. There are two types of fluorimeters: (i) filter based, or (ii) monochromator diffraction grating, these differ in the way excitation and emission light is isolated from the wider spectrum.

Monochromator based fluorimeters are generally restricted to the laboratory, while filter based units are used for field applications. Briefly, the light from the excitation source is directed through a series of lens and filters. When it reaches the sample the light is absorbed and some of the molecules in the sample fluoresce. The fluorescent (emission) light passes through a second series of lens and filters/monochromator and reaches a detector (usually a photodiode). This photodiode is normally located at 90° to the incident light beam to reduce the potential for spurious readings due to stray excitation light reaching the detector.

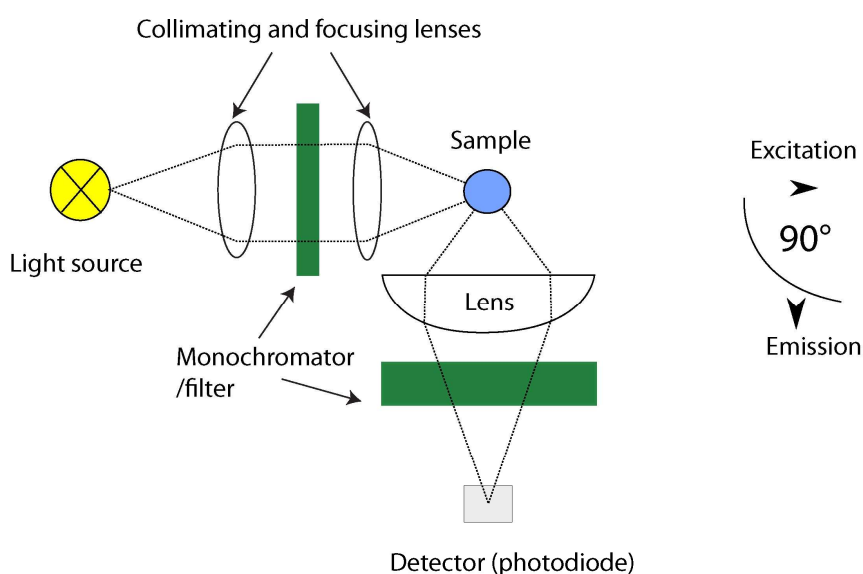


Figure 2: Schematic representation of a simple fluorometer design

1.2 MEASURING ORGANIC MATTER USING FLUOROMETERS

A significant proportion of chromophoric (light absorbing/coloured) organic matter is fluorescent when excited by light in the UV region. Using laboratory fluorometers that scan the full spectrum of excitation and emission wavelengths (Excitation Emission Matrix spectroscopy; EEM), distinct fluorescent peaks have been identified (Fig. 3). These are related to certain 'types' of organic matter, for example, humic-like fluorescence (Peaks A and C on Fig. 3) can be traced back to terrestrial production by vascular plants, while protein - like fluorescence (Peaks T and B; Figure 3) is largely related to in-stream production by algae and bacteria. Strong relationships between conventional water quality parameters and fluorescence peaks have been identified of particular interest are the correlations between: (i) dissolved organic carbon and humic-like fluorescence (A and C) and (ii) biochemical oxygen demand (BOD) and tryptophan-like fluorescence (Peak T).

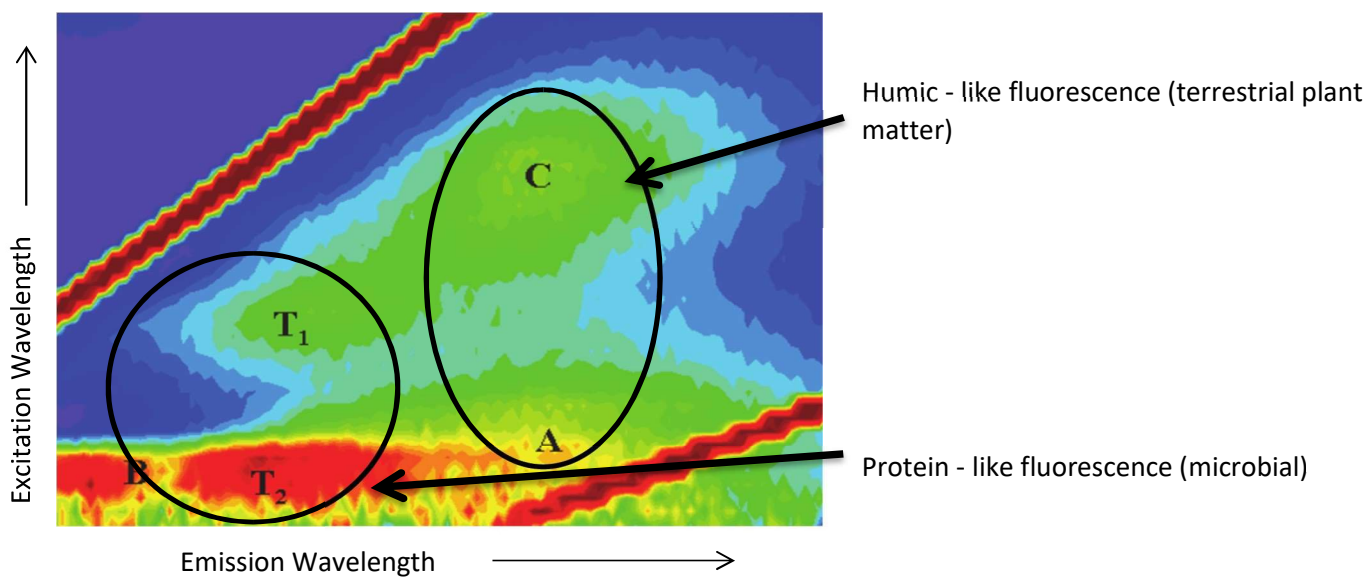


Figure 3: An Excitation Emission Matrix with the key peaks highlighted

2 INSTRUMENT SPECIFICATIONS

2.1 INSTRUMENT



Figure 4: Proteus Equipment Overview

1: Sensor Guard	7: Comms Cable
2: Sensor Array	8: Serial USB Adaptor
3: Housing	9: TLF/CDOM Fluorometer
4: Connector for comms	10: Turbidity Sensor
5: Calibration Cup	11: Temperature Sensor
6: Control Software	12: Location of Logging ON/OFF Switch

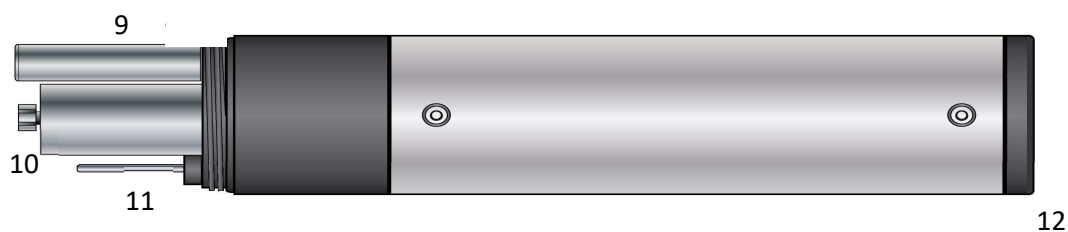


Figure 5: Schematic of Proteus Sensor

PROTEUS SPECIFICATIONS

Dimensions	OD 76mm, L 460mm
Weight	2-5kg* depending on specification
Temperature Operating Range	-5° C to +50° C (non-freezing)
Depth Rating	200m (except ISE sensors = 10m, TDG/Low Range Depth = 25m)
Supply Voltage	5-15vdc
Signal Outputs	RS232 (SDI12/RS485/Modbus optional)
Communications	RS232 & Optional Bluetooth Module
Sample Rate	≥1Hz
Internal Memory	4MB; >1,000,000 readings
Warranty	12 months (options to extend)

FLUOROMETER SPECIFICATIONS

Excitation (nm) ± bandpass (nm)	285 ± 10
Emission (nm) ± bandpass (nm)	350 ± 55
Detection limit (ppb)	3.00*
Dynamic range (ppb)	0 – 20000*
Accuracy	±1% of reading (0 – 10000 ppb)
BOD resolution (mg/l⁻¹)	0.1
Temperature compensation	Automatic (flexible- user defined)

TURBIDITY SENSOR SPECIFICATIONS

Turbidity range	0-4000 NTU
Accuracy	0- 600 NTU (±1%) / 600 -3000 NTU (±2%)
Temperature compensation	Automatic (fixed)

TEMPERATURE SENSOR SPECIFICATIONS

Temperature range	-5° C - 50° C
Accuracy	± 0.1 ° C

* Defined using synthetic tryptophan dissolved in deionized water

2.2 BASIC APPLICATIONS

2.2.1 MANUAL DATA COLLECTION

Manual Data Collection, also known as profiling, surveying, site-to-site measurements, etc., means the user is present at the monitoring site and uses a Data Display for observing measurements. This allows the user to make data-based decisions in the field in real-time and lets the user visit multiple monitoring sites in one day. The Data Display can be a compatible laptop, Amphibian2, or almost any Bluetooth enabled tablet or smart phone. The user makes note of measurements either with pen and paper or, preferably, by using the Proteus' Snapshot or Automatic Snapshot features. You might "snapshot" a series of measurements in one or more lakes or streams during the day and then download the data to your desktop PC that evening.

2.2.2 UNATTENDED LOGGING

Unattended Logging means that the user has set the multiprobe into Logging mode, deployed the multiprobe in the water and then left the site. The Proteus can run for weeks at a time with cable-supplied power or the optional Proteus integral battery pack. You can for instance set the instrument to take a set of readings every half-hour, anchor it in an estuary and return after several weeks to retrieve the instrument and download the data to a compatible PC, laptop, or Bluetooth enabled Android device.

2.2.3 TELEMETRY RELAY

Telemetry Relay means the user has connected the multiprobe to a telemetry device, deployed the Proteus in the in the water and then left the site. A cable connects the multiprobe to the telemetry system. The telemetry device uses wireless, satellite or GPRS communication to periodically report data collected by the Proteus to the user's office PC or to the cloud. In many telemetry systems, the user can also contact the multiprobe and request transmission of the most recent data and to force a wipe cycle. Telemetry Relay allows the user to read data without being present at the monitoring site and allows the user remote access to that data at any time. Telemetry is helpful in deciding when a trip to the field for multiprobe calibration or maintenance is necessary. Telemetry is also ideal in locations for which access is dangerous or expensive.

2.2.4 ONLINE MONITORING

On-Line Monitoring, also known as process-control monitoring, means that the multiprobe is connected to a PLC, SCADA system, etc. An example is monitoring the input to a water-treatment plant for BOD, salinity or chlorophyll. On-Line Monitoring allows the user or system to make water-quality-based decisions in real-time.

2.3 STATUS INDICATOR LIGHTS

The Proteus and the SDI-12 adaptor (see section 6.5) have three light-emitting diodes (LEDs) mounted on the circuit board top visible from the outside through the transparent housing (or on the top of the sensor housing in the stainless model). These LED lights indicate the instrument's operating status and can be used to troubleshoot problems

LED	Proteus	SDI-12 adaptor
Green	When the sensor is receiving adequate operating voltage through the cable this LED blinks every second	When the converter's CPU is ready to perform this LED pulses
Yellow	The yellow LED blinks when the sensor is receiving RS-232 communications.	The yellow LED is used for factory diagnostics .
Red/Blue	The red LED blinks during power-up .	The blue LED remains on when powered up

2.4 ACCESSORIES



Figure 6: Flow Cell

If it is more convenient to bring the sample to the Proteus than the Proteus to the water, for instance when monitoring a ground-water well, you can simply screw a Flow Cell onto the Proteus as you would normally screw on a sensor guard.

Be sure to limit the pressure in your sample lines to 15 psi/1 bar/10m H₂O so that you don't damage the flow cell or sensors.

3 COMMUNICATION SOFTWARE

3.1 SYSTEM REQUIREMENTS

The Proteus Control Software is designed to run on Microsoft Windows operating systems. The programme itself is very small and does not need any significant resources; as such any old laptop or PC that can run MS Office should suffice.

3.1.1 CONTROL SOFTWARE

To install the software required to communicate with the Proteus:

- Insert Proteus Control Software disc into the PC's CD-ROM drive.
- After a few moments, verify that your PC desktop has a Proteus Control icon
- Once installed, the Proteus Control Software will automatically start but close this to complete installation of the USB driver.

3.1.2 SERIAL ADAPTER DRIVERS

Your Proteus communicates with your PC via a USB Serial Adapter plugged into a USB port and your PC needs a program in order to communicate with the USB Serial Adapter. Here's how to install that program onto your PC:

- Plug the USB adaptor into any USB port on your PC
- Select install software automatically when prompted by Windows
- PC should find the software on disk to install automatically
- Verification box will appear with hardware installed successfully

3.2 INTERFACE SCREEN

When the Proteus is plugged into a computer via the USB connector and the software is started the interface screen below (Fig. 6) will appear. Initially the software will search for the Proteus on available COM ports, after about 20 -30 secs the connection will be completed and readings will start to scroll down the page.

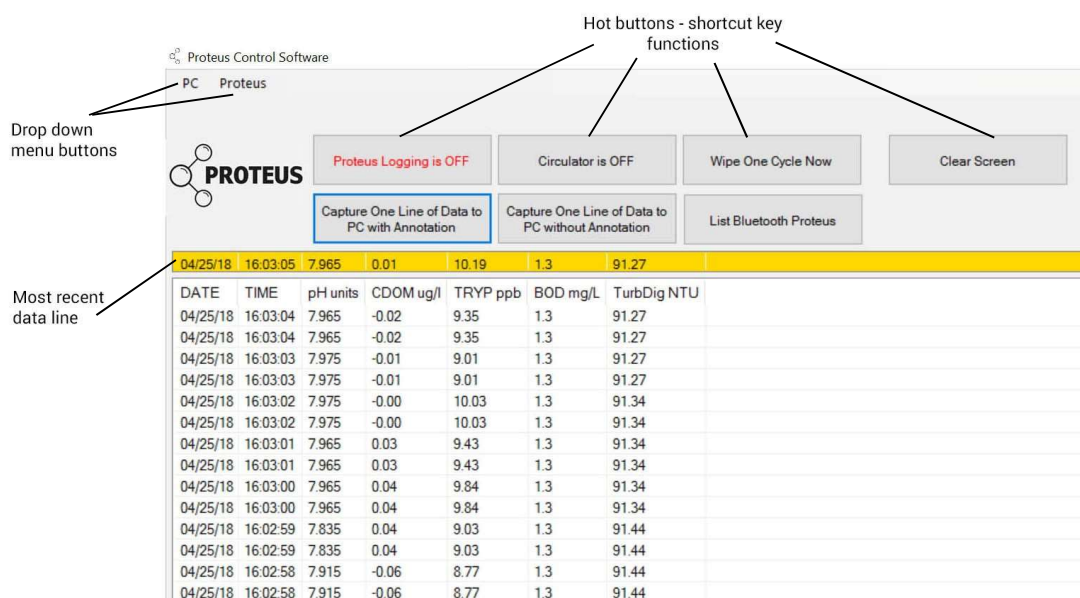


Figure 7: Proteus Control Software (PC) Overview

3.3 HOT BUTTONS

The Hot Buttons are quick start up link for some of the most frequently used functions available:

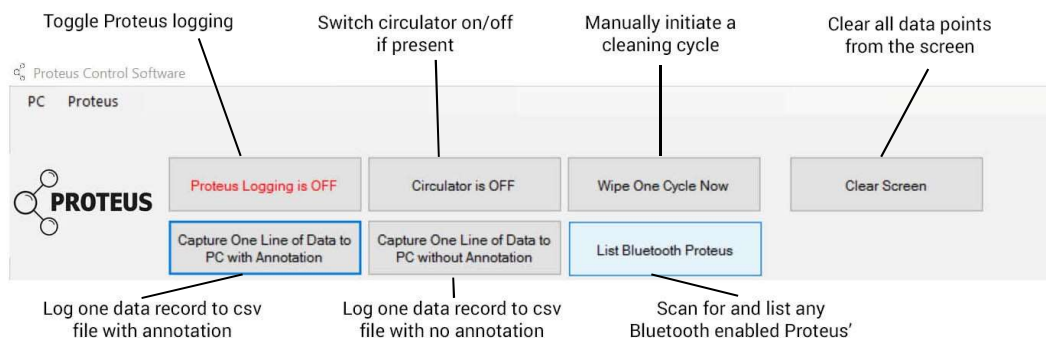


Figure 8: Hot Buttons on the Proteus Control Software (PC)

Proteus logging is OFF (or ON) Hot Button is used to enable or disable the logging function.

This button doesn't actually turn logging on or off – you do this on the sensor unit (see Fig. 5). It lets you tell the unit that you intend to deploy in the field for unattended logging. Generally, logging should be off – only turn logging to ON only when you're preparing for unattended deployment.

Circulator is OFF (or "ON") Hot Button is used to turn the circulator ON and OFF.

Circulators are seldom used except when you have a Clark-type dissolved-oxygen sensor.

Wipe one cycle now Hot Button is used to activate one cycle of the turbidity sensor's wiper.

Capture One Line of Data to PC without Annotation Hot Button is used to save the most recent line of data (as shown in the yellow band on the Main Screen) to your Snapshot file (see Section 3.4.1).

Capture One Line of Data to PC with Annotation Hot Button is used to save the most recent line of data (as shown in the yellow band on the Main Screen) to your Snapshot file, along with a brief note that you might wish to append to the data. Type that note in the annotation box; the note will be saved in your Snapshot file (see Section 3.4.1).

Clear Data from PC screen Hot Button is used to remove the data you see on the screen and start over with only the most recent data.

3.4 DROP-DOWN MENUS

The Proteus has two Drop-Down Menus; 'PC' and 'Proteus'. Within these two menus all the software settings and calibration tools can be accessed

3.4.1 PC MENU

The PC menu has six choices:

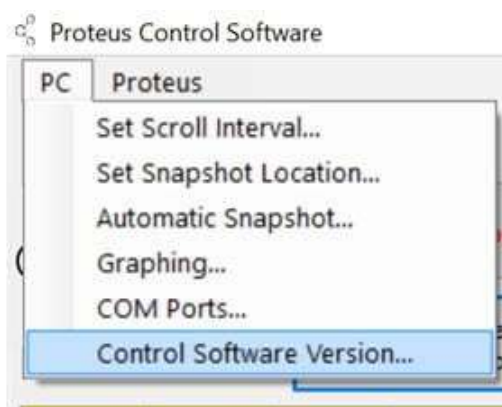


Figure 9: PC Drop Down Menu

FIGURE 8. PC DROP DOWN MENU

Set Scroll Interval: This option is used to change the time the lines of data on your PC or Amphibian screen update. You can click on a specific scroll interval or write in your own:

Set Snapshot Location: A "Snapshot" is what happens when you choose to log, or store, one line of data. That line can be representative of, say, stabilized readings at 10 meters in a particular lake or any other line of data you find interesting. Use the *Set Snapshot Location* to specify the file in which your snapshots are to be stored.

Notice that the Snapshot File location is listed on the bottom line of the Main Screen for your convenience.

Automatic Snapshot. This option enables the used to log data automatically. The data is stored in the Snapshot File as determined by *Set Snapshot Location*.

In *Automatic Snapshot* data is logged at the same interval as they are displayed on your PC or Amphibian screen when you're not in Automatic Snapshot. For instance, if you have set your scroll interval to 10 seconds (see Section B3a), Automatic Snapshot will record data at 10-second intervals.

Graphing. Click on graphing to see your Proteus data in graphical, rather than tabular form.

COM Ports. The Proteus Control Software automatically searches all active USB ports until it finds a Proteus. However, you can use the “COM Ports” button to change the USB port that your Proteus Control Software uses to communicate (useful if 2 or more Proteuss are connected to a single PC).

Control Software Version: Click this icon to get a screen that tells you the software.

3.4.2 PROTEUS MENU

The Proteus Menu has eight choices:

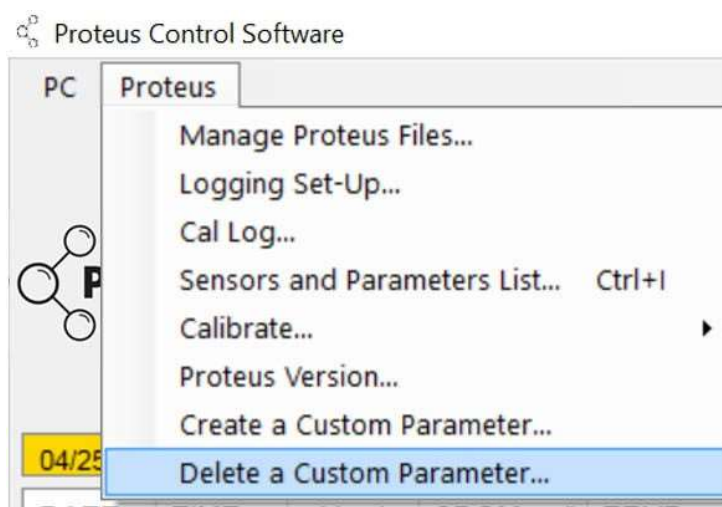


Figure 10: Proteus Drop Down Menu

Manage Proteus Files. This option enables the user to view all the data files stored in your Proteus. Highlight the file(s) you’re interested in by clicking on it. Then with the other buttons on the screen you can then view that file on your PC screen, delete that file, or export it to your PC (via the Save As function standard to Windows).

Logging Set-Up. The Logging Set-Up screen lets you change any or all of the Proteus logging settings. You can click on your preferred logging interval. You can also elect to append any new data to a file that already exists in the Proteus by clicking *Browse Proteus* and clicking on *OK*, or you can create a new Proteus Log File by typing the new file name under *Log File Name*.

Note: the active Logging File name is displayed in the bottom line of the main screen.

Calibration Log. Click on the *Cal Log* button to see the calibration record. This is a permanent record of all calibration changes for your Proteus.

Sensors and Parameters List. This option will display a list of all the parameters supported by the Proteus. Parameters are enabled by clicking in the box to the left of the parameter name. The order of the enabled parameters in this list is the order in which the parameters will appear on: (i) your PC or Amphibian Main Screen, (ii) logging files and (iii) Snapshot files. You can change the parameter order by clicking on the parameter name and then moving the highlighted name up or down by clicking on the up and down arrows at the bottom of the screen.

Calibrate. This opens a second drop-down menu (Fig. 8) of all the parameters that can be calibrated in a Proteus. Click on the parameter you wish to calibrate to see its Calibrate screen. This screen has calibration instructions for the specific parameter and shows the current reading for that parameter.

If your calibration requires a calibration standard, type your calibration standard value where it says *enter calibration value*. When the parameter reading has stabilized, click on the *OK* button. If your calibration has an acceptable *SRF* (*Sensor Response Factor*) the calibration will be accepted and you will be returned to the Main Screen. If the *SRF* is not acceptable, a box will pop up and caution you about the feasibility of your calibration. If you click on *OK*, the calibration will be accepted despite a deviant *SRF* and you will be returned to the Main Screen). If you click on *Cancel*, you'll go back to the Calibrate screen See [Section 5](#) for detailed information on the calibration procedure.

How do I know if I need to calibrate?

The simple answer is that frequent calibration will give you better data. The more meticulous you are with calibration, the better data you will gather. If you are uncertain whether you need to calibrate, check your sensors against a known sample. If the reading is within the accuracy specification and/or your accuracy expectations, there is no need to calibrate.

Experience and your program's accuracy expectations will help determine calibration frequency for the various sensors. If, for instance, your reservoir discharge is hovering near the regulatory minimum for dissolved oxygen, you should pay special attention to DO calibration frequency and technique. On the other hand, if a conductivity accuracy of +/- 10% is OK, you needn't calibrate conductivity very often.

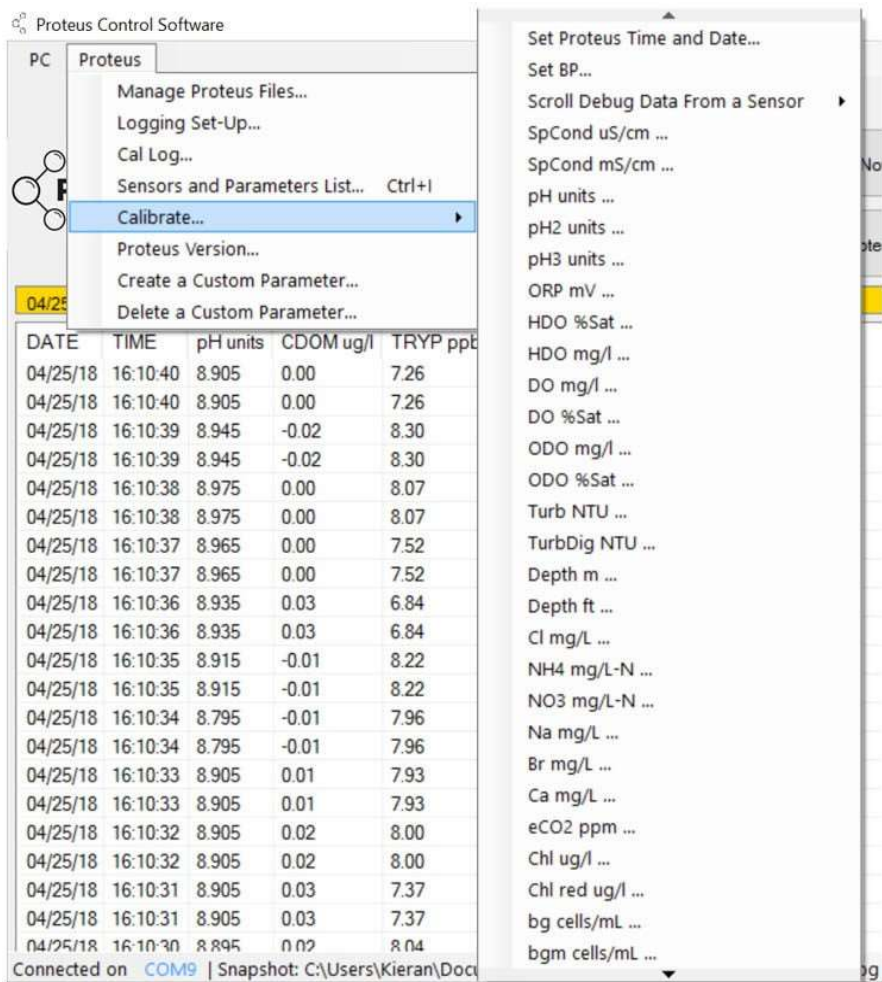


Figure 11: Calibration Drop Down Menu

Proteus Version. Click this button to see the version number for the software that your Proteus is using.

Create a Custom Parameter. This option enables users to create new parameters that will behave just like other parameters (i.e. temperature, turbidity and tryptophan). An example of this may be the creation of a parameter - suspended solids (TSS) based user defined relationship between turbidity and TSS for a site of interest.

To make this happen, click on the Proteus pull-down menu and click on Create Custom Parameter. Follow the instructions to name your new parameter, specify the units that you wish the new parameter reported in (e.g. mg/l for TSS) and tell the Proteus how to calculate your new parameter using operators as you would in Excel.

Note: enclose the entire expression in parentheses. After creating or deleting a parameter, restart the Proteus. Custom Parameters cannot be created with the Amphibian Control Software.

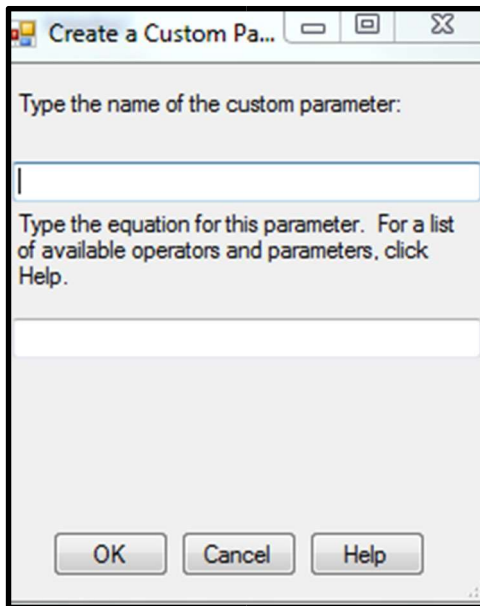


Figure 12: Custom parameter screen

4 INSTALLATION

Due to the versatility of the Proteus, it is possible to use the sonde for a range of applications spanning a variety of freshwater habitats (natural – engineered). In this section installation recommendations are outlined for the two most commonly encountered applications. The Proteus has internal logging capabilities or can be hooked up to an external data logger (see Section 6). If internal logging is required ensure logging has been activated via the control software interface (see Section 3). Then connect the external battery pack to the Proteus or, for internal battery packs, flip the ON/OFF switch plate to *ON*. Logging will continue until power (external battery pack) is removed/ depleted or the switch plate is set to *OFF*.

4.1 OPEN WATER INSTALLATION

A vertical clearance of 75 mm (as provided by the Sensor Guard) is required for optical sensors (fluorescence and turbidity) as backscatter can cause spurious records. The sensor should always be installed with the Sensor Guard securely fastened and, whenever possible, with the sonde in the vertical position (Figure 13). In larger streams and rivers where highly variable flows are anticipated the sonde should be adequately protected from floating debris. We advise installing the sensor in a perforated stilling tube (Figure 14), to both protect the sensor and reduce ambient light interference. To secure the sonde use large cable ties attached to at least two points on the sonde (avoid using clamps as this can damage the instrument). Avoid installation in locations where deposition of sand/silt is likely.

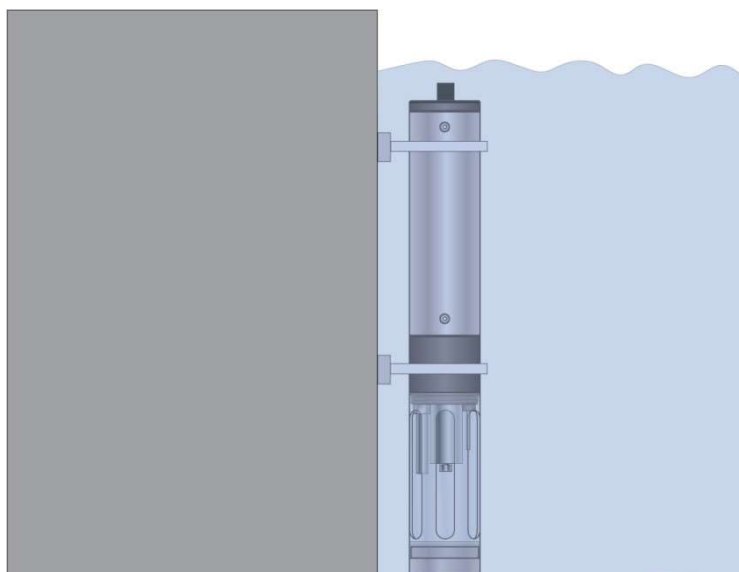


Figure 13: Installation of Proteus in open water with Sensor Guard and support structure

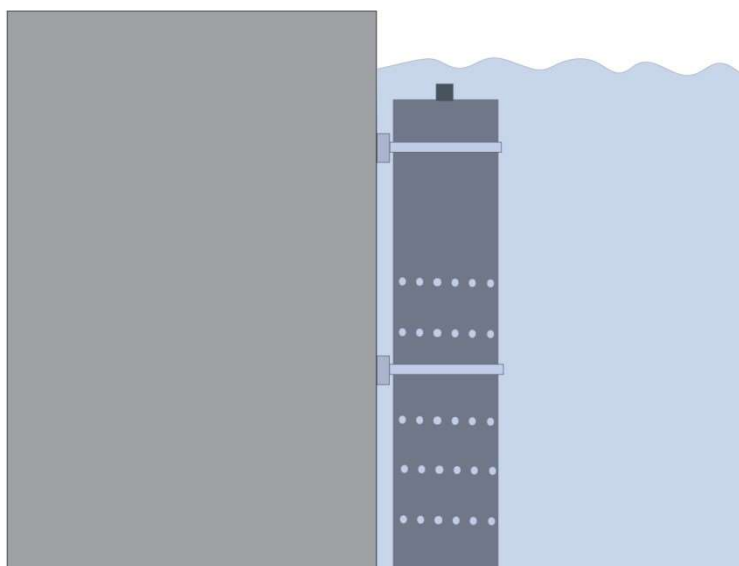


Figure 14: installation of Proteus in perforated stilling well for protection

4.1 FLOW CELL INSTALLATION

An alternative installation option involves non submersible deployment, usually associated with a peristaltic pump through or process applications. If this is desirable attach the flow-cell (Figure 15) to the Proteus in place of the sensor guard and attach the feed line to the barbed connectors (NOTE: ensure the pressure does not exceed 15 psi/1 bar/10mH₂O). Ensure all connections and hoses including barbed connectors as shown in figure 15 have the correct pressure rating. It is recommended that any debris is filtered from the feed line using a mesh screen in line, 250 - 500 μ m is normally sufficient for this purpose.



Figure 15: Proteus flow cell with barbed connectors.

4.2 ROUTINE MAINTENANCE

To ensure accurate and reliable data during longer term installations, regular cleaning of the sonde and sensors is recommended. We suggest that if routine calibration of the sensors is also required that this coincides with your cleaning regime. See **Section 5** for more details.

5 CALIBRATION

5.1 BASICS OF PARAMETER CALIBRATIONS

The Proteus never guesses parameter values so you have to calibrate it from time to time by simply telling the instrument what it should read in a calibration situation for which the correct parameter value is known. Here's the general procedure; instructions for specific parameters will follow:

- 1 Observe all health and safety and handling and disposal instructions according to Manufacturer's handling instructions and MSDS for calibration fluids and waste products.
- 2 Good hygiene and housekeeping will help ensure good results
- 3 Rinse sensors and calibration cup thoroughly (more than once may be required) with DI (deionized) water especially if you have been using other calibration solutions. Pour the water into the calibration cup, position the "stopper" side of the lid on top and shake the Proteus vigorously to remove traces of old calibration solutions – repeat if necessary
- 4 Clean the sensor and perform any necessary sensor-specific maintenance.
- 5 Select a calibration standard whose value is close to the values you expect to see in the field. For best results use fresh calibration solutions and discard once they have been used.
- 6 Rinse the sensors twice with a small quantity of your calibration standard. Discard the used calibration standard.
- 7 Immerse the sensor in the calibration standard. This is usually accomplished by pouring the standard into the Proteus' clean calibration cup once it has been screwed onto the Proteus housing. Secure your Proteus with the sensors pointing up and fill the calibration cup with your calibration standard. Make sure the standard covers the sensor entirely and that it also covers the thermistor for those parameters that are temperature-compensated. For turbidity sensors and other fluorometers fill the cup to at least 40mm above the sensor's lens surface.
- 8 Select the parameter to be calibrated by clicking on the Proteus pull-down menu in the Home Page, then clicking on *Calibrate* and then clicking on the parameter you wish to calibrate. First, enter the calibration value and press *enter*; when the reading has stabilized, press *enter* to calibrate. The Proteus will report the resulting Sensor Response Factor (SRF); then press *Y* to accept the calibration, *N* to back up one step, or *Exit* to leave the sensor uncalibrated.

5.2 CHOOSING CALIBRATION STANDARDS

For best results, choose a calibration standard whose value is close to what you expect to see in the field. For example, calibrate with a 1413 $\mu\text{S}/\text{cm}$ Specific Conductance standard if you expect to see Specific Conductance readings between 500 and 1000 $\mu\text{S}/\text{cm}$ in the field. Calibrating with a sea water standard or a very low standard would not be appropriate in that case. Similarly, if your waters tend toward the acidic, calibrate with a 4-buffer instead of a 10-buffer.

If you are moving your multiprobe across wide ranges of water conditions, you may wish to recalibrate to match the new situations. For instance, if you are measuring a clear lake during the morning and a high-sediment stream in the afternoon you might consider recalibrating at noon with a high-range turbidity standard.

Sensor	Standard Method of Calibration	Available Calibration Solutions	Comments
Temperature	never requires calibrating	N/A	
pH / pH reference	2 or 3 points	pH 4, pH 7, pH 10	pH7, pH 10 most common
ORP	1 point	ORP Standard 200 mV	
Conductivity	1 point	CD Standard, 0.5 Molar, 58670 Micro S CD Standard, 0.1 Molar, 12856 Micro S CD Standard, 0.01 Molar, 1412 Micro S CD Standard, 0.001 Molar, 147 Micro S	brackish/saltwater borderline brackish typical freshwater very pure fresh/glacial
Reference Electrode	calibration not required	N/A	replace pH electrolyte solution at routine calibration
Depth	adjust for barometric pressure	N/A	recalibrate at deployment site for best accuracy
Turbidity	2 points	0 NTU, 10 NTU, 100 NTU, 400 NTU	calibrate near expected value
HDO (Optical DO)	calibrate at 100% saturated water	DI water -shake vigorously to oxygenate	set BP before calibrating, recal at deployment site for best accuracy
Chlorophyll	2 points	secondary solid or 40µg/L solution or lab sample	
Rhodamine	2 points	secondary solid standard or rhodamine	
Blue Green Algae	2 points	secondary solid standard or lab sample	
Ammonium (NH ₄ ⁺)	2 points	Lo 4.63 mg/l; Hi 46.3 mg/l	
Chloride (Cl ⁻)	2 points	CD Standard 147 Micro S CD Standard 1412 Micro S	enter 34.3 during calibration for low enter 319.3 mg/L for high

5.3 CALIBRATION RECORD ('CAL LOG')

Every Proteus has a dedicated data file called CAL.LOG. The CAL.LOG records every calibration that your instrument has accepted. In this file are the time and date of the calibration, the parameter calibrated, the reading before the calibration was accepted, the reading after the calibration was accepted, the SRF and a few other details. If you wished to know, for instance, the last time that Conductivity was calibrated, the Calibration Record would tell you when the most recent Conductivity calibration was accepted, the value of the calibration standard and the instrument's reading in the standard before the calibration was made (to tell you exactly how much the instrument was changed during calibration).

5.4 SENSOR RESPONSE FACTOR (SRF)

Also included in the Calibration Record is each calibration's Sensor Response Factor (SRF). Suppose that a typical Conductivity sensor reports 100 μA in a 1413 $\mu\text{S}/\text{cm}$ standard. If your Conductivity sensor reports 100 μA in that same calibration solution, then your SRF is 100% (some parameters, such as pH, have a more complex SRF calculation, but the effect is the same). If your response is 80 μA , your SRF would be 80%. When you press the OK button to accept a calibration, the Proteus automatically accepts your calibration if the SRF is between 60% and 140%. If the SRF falls outside that range you will be cautioned to check your standard value, make sure the sensor is clean, make sure the reading has stabilized, etc. But you can elect to accept any SRF.

5.5 UNITS/CONVERSION FACTORS

Turbidity: The units reported are NTU (FNU = NTU = FTU) but are essentially FNU as a formazin standard is used and the sensor measures nephelometric turbidity

Tryptophan like fluorescence: the units reported are ppb ($\text{ppb} = \mu\text{g}/\text{l}^{-1}$). However the raw fluorescence output is preferred (i.e. mV) then this can be provided as an additional parameter.

Temperature: the units reported are $^{\circ}\text{C}$ ($^{\circ}\text{F} = ^{\circ}\text{C} \times 1.8 + 32$; $\text{K} = ^{\circ}\text{C} + 273.15$)

BOD equivalent: the units reported are mg/l^{-1}

5.6 FACTORY CALIBRATION

The sensor is delivered with a 2 point factory calibration for both turbidity and tryptophan like fluorescence. A generic calibration for BOD can be provided (Figure 16), however this is only suitable for relatively low range applications $< 20\text{mg}/\text{l}^{-1}$. It is always advisable to conduct a site specific calibration for BOD if a high level of accuracy is required or the sensor is to be deployed for an extended time period (see Section 5.7). For high range applications where event based variability is not anticipated a dilution series can be created in the laboratory and a BOD calibration created from this.

NB Custom calibrations can be provided on request. The following are some examples of the possibilities (i) 5 point calibration across a user specified range (this is determined by the application) (ii) calibration using matrix water dilution series or (iii) calibration using user specified standard material (e.g. the turbidity sensor is normally calibrated with a formazin solution but user can specify polymer bead calibration).

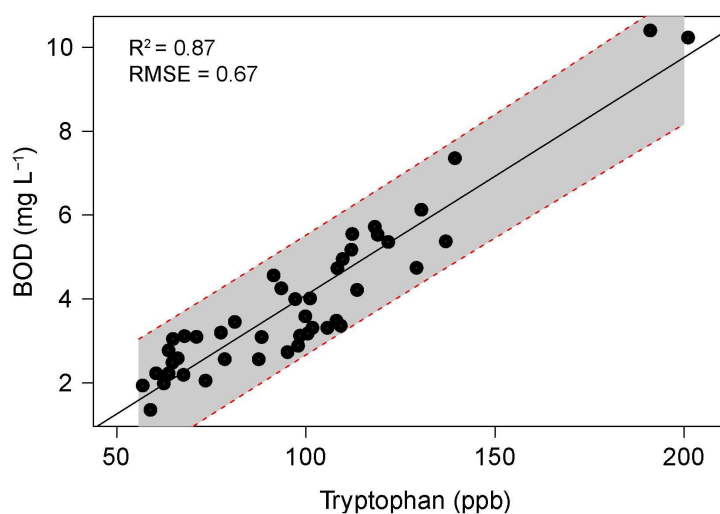


Figure 16: Proteus Instruments default low range relationship (turbidity and temperature corrected tryptophan).

5.7 TURBIDITY CALIBRATION

Turbidity is measured as the fraction of an infrared light beam that is scattered at 90° to that beam. More particles in the water mean more of that light is scattered, so the Turbidity reading is higher. Any material that accumulates on the optical surfaces of the Turbidity sensor is indistinguishable from material in the water, hence the wiper fitted to the Turbidity sensors in the Proteus to clean the window(s).

Turbidity sensors require no regular maintenance, but you might check occasionally to make sure the optical window (i.e. the little glass port on the front of the sensor) has not been damaged by overzealous wiping.

DO NOT MANUALLY FORCE ROTATE THE WIPER ARM

Turbidity uses a two-point calibration; one point is zero turbidity and the other point should be a standard approximating the turbidity of the water you intend to monitor.

Make sure you use enough calibration standard to cover the sensor's "optical volume" – imagine a tennis ball stuck on the end of the sensor; make sure there are no objects in the volume represented by that ball. One common method is keeping calibration solutions in one-litre, dark, wide-neck bottles with a non-reflective surface.

For the zero calibration:

- Make sure the Turbidity sensor is fully immersed (i.e. at least 40mm of solution over the sensor) in zero-turbidity standard and has an unobstructed optical path.
- Follow the Proteus Control Software's calibration instructions.

For the other calibration point:

- Rinse your sensors several times with the standard you'll use for calibration.
- Make sure the Turbidity sensor is fully immersed (i.e. at least 40mm of solution over the sensor) in the standard and has an unobstructed optical path.
- Follow the Proteus Control Software's calibration instructions.

A clean wiper means better measurements. If the wiper pad has deteriorated or is clogged with debris from your water (algae, silt, etc.), you should change it. For best results, you might consider changing the wiper pad prior to each long-term deployment.

DO NOT MANUALLY FORCE ROTATE THE WIPER ARM

To change the wiper pad:

- Make sure you have the 1.5mm hex key and a new pad for the wiper. Loosen the small set screw on the wiper arm.
- Remove the wiper pad from the wiper arm and replace the pad.
- Place a new wiper arm on the motor shaft so that the set screw faces the flat spot on the motor shaft.
- Gently press the wiper pad against the face of the probe until the pad is compressed to roughly three quarters of its original thickness. It is important that the wiper arm does not make contact with the probe face – only the pad should be in contact. A gap of 0.5 mm between the wiper arm and the probe face is typical when a new pad has been installed. Another way of setting the pad gap is to place the pad such that you can slide a small piece of paper under the pad, but snug enough that the pad will hold the paper.
- Tighten the set screw.

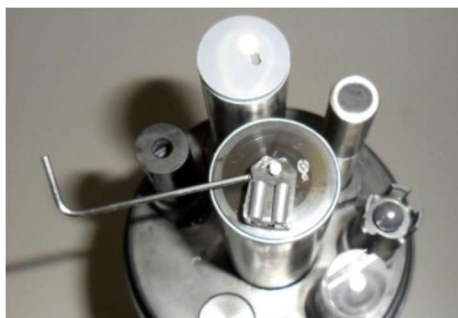


Figure 17: Turbidity Wiper Replacement

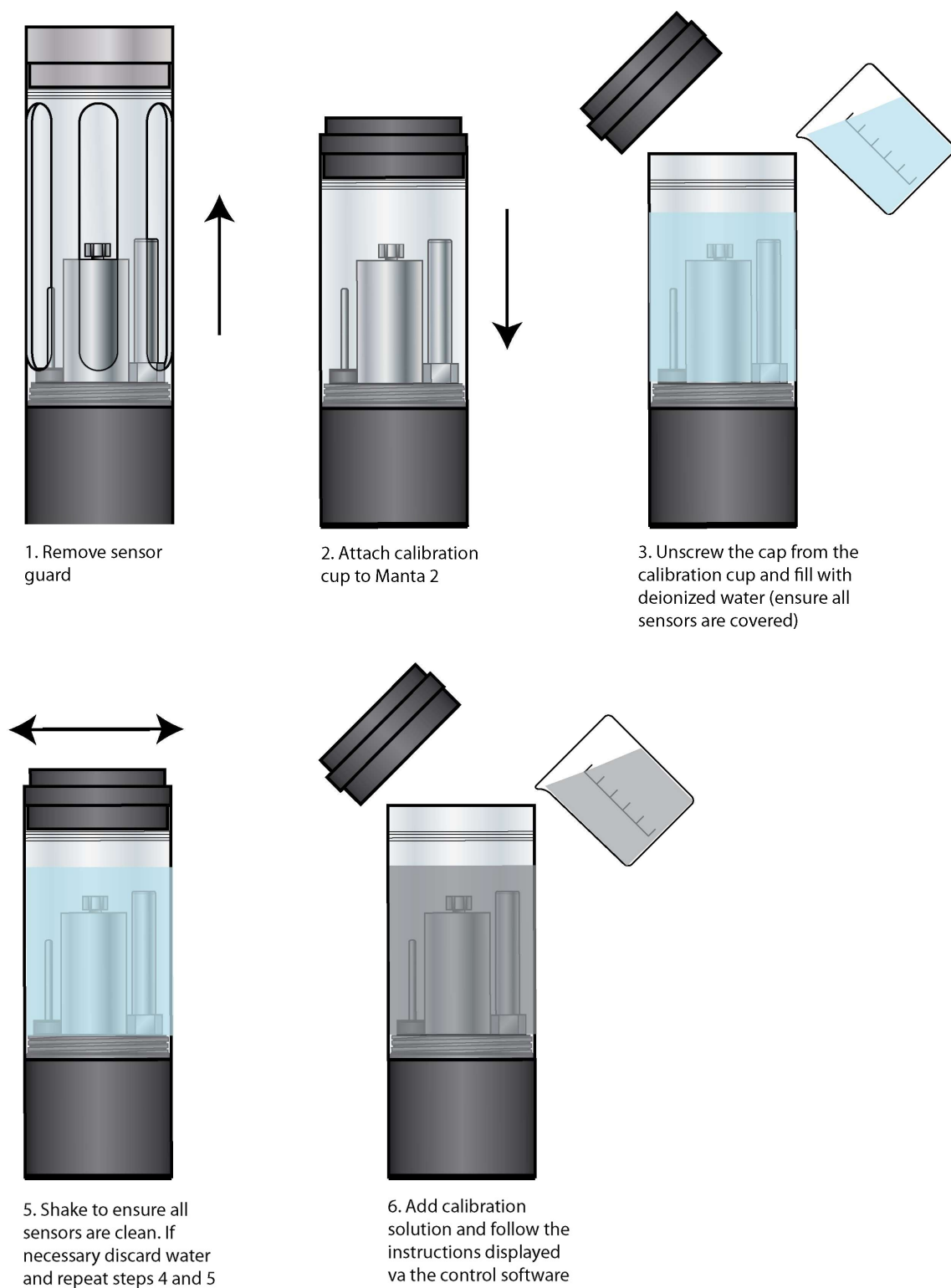


Figure 18: Schematic representation of the calibration procedure for turbidity

5.8 TRYPTOPHAN CALIBRATION AND COMPENSATION

5.8.1 TYPICAL RANGES

HABITAT	TRYPTOPHAN LIKE FLOURESCENCE	BOD ₅
Rivers	20-60ppb	0-5 mg/l ⁻¹
Treated effluent and polluted rivers	60-1500ppb	5-60 mg/l ⁻¹
Primary/Secondary effluent	800-6000ppb	40-300 mg/l ⁻¹
Raw municipal sewage	2000-12000ppb	100-600 mg/l ⁻¹
Contaminated industrial effluent	8000->10000ppb	400-6000 mg/l ⁻¹

5.8.2 TEMPERATURE COMPENSATION

Fluorescence is a temperature sensitive measurement as at higher temperatures the signal is 'quenched' or attenuated (see figure 19 for laboratory example). The fluorescence signal can be corrected for temperature quenching following methods outlined by Khamis *et al.* (2015). The Proteus is placed in the solution to be measured and warmed and cooled across the range expected during field monitoring (usually 5 - 25 °C). Readings are then logged and the readings are then used to create a regression relationship between temperature and tryptophan like fluorescence. The ratio of the slope: intercept (ρ) has been shown to be relatively constant regardless of fluorophore concentration and thus provides a robust temperature compensation coefficient.

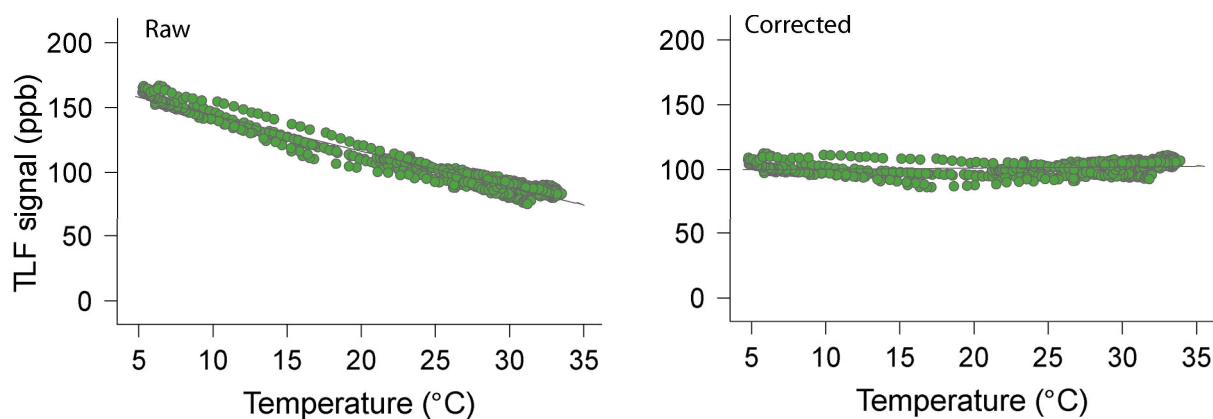


Figure 19: Raw and temperature corrected tryptophan like fluorescence (TLF) of a laboratory standard

5.8.3 TURBIDITY COMPENSATION

As with any optical measurement the accuracy of the measurement is dependent on the clarity of the sample volume. In the case of tryptophan like fluorescence we observe both amplification and attenuation of the signal depending on the amount of particle suspended in the water column. At very high concentrations of suspended particles (i.e. turbidity > 300NTU) attenuation of the signal becomes significant whilst amplification is most pronounced between 30-100 NTU.

Proteus Instruments have developed and patented robust laboratory based compensation algorithms that can be employed to correct for influence of turbidity. However, as particle size can influence the response the fluorescence sensor exhibits it is important to know some information about the sediment dynamics in your study catchment. Alternatively a site specific, field based calibration can be constructed between BOD and

tryptophan like fluorescence can be established (See 5.7). This compensation factor is optional and is advised when highly variable fluorescence dynamics are anticipated or when the fluorescence signal is of interest rather than the calibrated BOD reading.

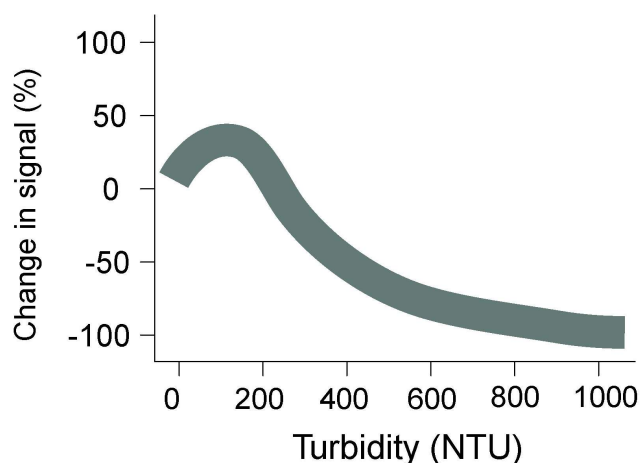


Figure 20: Change in fluorescence signal with turbidity

5.8.4 VERIFICATION AND CALIBRATION

The optical sensors in the Proteus display minimal drift, however we recommend routine verification with a blank in the field Figure 20. A full calibration is tryptophan like fluorescence to small (clay/fine silt) recommended every 6 -12 months, suspended particles depending on the application. Proteus Instruments offer a calibration service (see 5.6); however, this can be conducted by the end user if laboratory facilities are available (technical document available on request).

5.9 FIELD BASED CALIBRATION

For accurate and repeatable measurement of BOD a site specific calibration is recommended. This should ideally encapsulate a high flow event when rapid changes in turbidity (sediment concentrations) and organic matter load are likely to occur. Proteus Instruments can offer rental of refrigerated pump samplers (ISCO Avalanche) for storm sampling. Collected samples can then processed at an accredited laboratory.

Alternatively, a generalized relationship between temperature/turbidity corrected tryptophan like fluorescence and BOD can be used however it is important to note that these have been derived from studies on a subset of all possible applications so will act as more of an indicator of organic enrichment rather than a quantitative measurement of BOD. See below for the generalized relationships based on samples collected from agricultural and urban river systems.

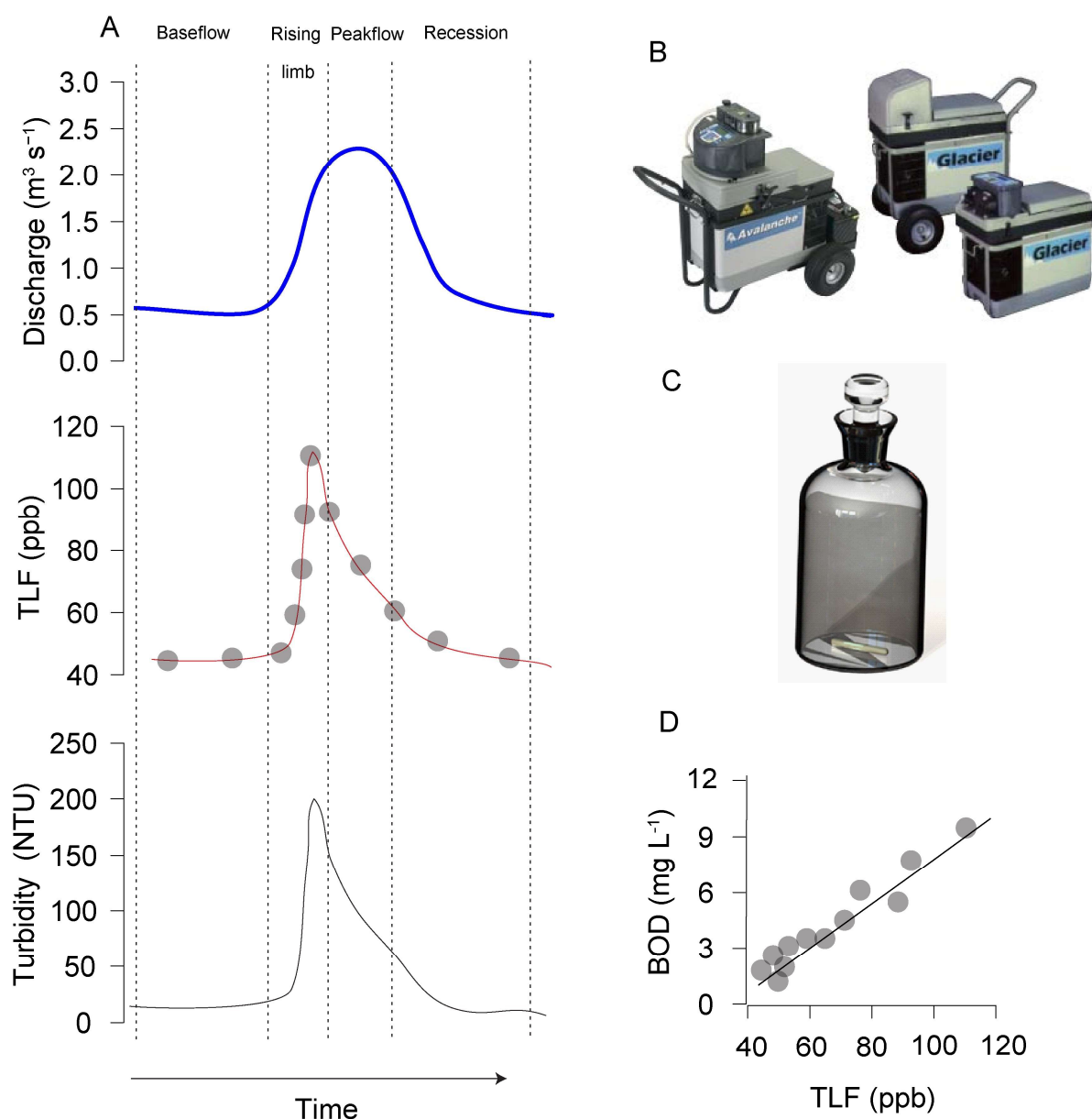


Figure 21: Schematic of Field Based Calibration Procedure

The above figure represents the calibration procedure required: **A.** displays the components of a storm hydrograph. To ensure a good calibration it is important to sample at a range of points in time across the hydrograph to get a wide range of TLF values and turbidity readings. **B.** displays the automatic pump sampler Proteus Instruments can provide for sampling storm events. **C.** If users do not have access to lab facilities Proteus Instruments can arrange for BOD sample bottles to be delivered and collected after sampling and analysis then conducted in an accredited laboratory. **D.** a site specific BOD- TLF relationship can be established and real-time continuous measurements of BOD can be provided.

5.10 CALIBRATION OF OTHER PROBES

5.10.1 TEMPERATURE



The Temperature sensor is an electrical resistor (thermistor) whose resistance changes predictably with temperature. The sensor is protected by a stainless-steel tube. Thermistors are very stable with time and so do not require calibration.

5.10.2 DISSOLVED OXYGEN



The optical dissolved-oxygen sensor comprises a blue-light source, a sensing surface and a red-light receiver. The sensing surface is an oxygen-active compound stabilized in an oxygen-permeable polymer, usually silicone. When the sensing surface is exposed to water (or air, for that matter), oxygen diffuses into the sensing surface according to the amount (partial pressure) of oxygen in the water. The oxygen active compound fluoresces – that is, it absorbs energy in the form of blue light and then emits energy as red light. In each measurement cycle, the blue light is first turned on and then turned off. The red-light receiver measures the time it takes after the blue light is turned off for the fluorescence to die off. This value is proportional to dissolved oxygen.

The sensor output is corrected for the temperature and salinity of the water.

Proteus is an advocate of the “air-saturated water” calibration method – that’s different from the “water-saturated air” calibration commonly used in the past. Here are the steps to air-saturated water calibration:

- Make sure your instrument’s Barometric Pressure setting is accurate.
- Put a half-litre of tap water in a litre jar, put on the lid and shake the jar vigorously for one minute. Take the lid off the jar and let the water stand for about five minutes to let the air bubbles float out.
- Screw your calibration cup onto the Proteus housing. With the sensors pointed upward, fill the calibration cup until your aerated water covers the DO cap by a centimetre or so.
- Wait a few minutes for the temperature to equilibrate.
- Follow the Control Software calibration instructions – remember that you are calibrating % sat, not mg/l, so select % sat from the list.

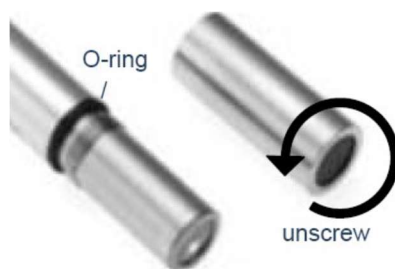
The manufacturers of optical-DO sensors recommend that you not calibrate the zero-DO point. However, we support zero-DO calibration in the Proteus software and think it’s a good idea to check your sensor’s zero from time to time in any of three ways:

- Dissolve a few grams of sodium sulphite and a pinch of cobalt chloride in a half-litre of tap water. You can buy this solution ready-to-use but be careful not to aerate the solution by pouring it numerous times.
- Prepare zero-oxygen water by bubbling nitrogen through water. Use bottled gas and an aquarium-type air-stone. After bubbling the gas through a litre of water for 10 minutes you should have a good zero.
- The simplest way to check zero response is with nitrogen gas. Wrap the sensor-end of your Proteus with a plastic bag and feed nitrogen gas into the bag. Make sure there’s another hole at the opposite end of the bag for the air to escape. (If you’re using a high-pressure gas bottle, please use a two-stage regulator.)

Optical dissolved-oxygen sensor maintenance is little more than occasionally cleaning the sensing surface (the black material; about a centimetre diameter) with a cloth and soapy water.

Optical dissolved-oxygen sensors *usually* have very low drift rates (compared to the old Clark sensors), so practice will show you how often to calibrate your optical sensor. You might also find that one or other of the calibration points does not require calibration every time you set the other point.

The tip of the optical dissolved oxygen sensor (HDO) must be replaced periodically, typically once every 4 years. If your SRF reports less than 100% or if you notice that the sensor's readings are getting noisy (i.e. jumpy), then it's probably time to change the tip by unscrewing the old tip and replacing it with a new tip. Recalibrate and you're ready to go.



5.10.3 CONDUCTIVITY



Proteus uses the four-electrode method to determine water conductivity. Two pairs of graphite electrodes are situated in a stable geometry.

A constant voltage is applied to one of each electrode pair and the amount of current required to maintain that voltage is measured. As the conductivity of the water increases, the current increases.

The zero point for the sensor is set electronically, so you need only set the "slope" point:

- 1 Fill the calibration cup with your conductivity standard to cover the conductivity sensor. Tap gently on the cup to make sure there aren't bubbles trapped in the conductivity sensor.
- 2 Follow the Control Software's calibration instructions.

The Proteus normally reports Specific Conductance – that's Conductivity standardized to 25°C. Your reading is thus the conductivity of your water if that water were heated or cooled to exactly 25°C. Conductivity has several other forms, Total Dissolved Solids (TDS) and Salinity. You can't calibrate TDS or salinity directly because they are calculated from Conductivity. You can, however, "calibrate" TDS with a TDS standard by adjusting the conductivity calibration point up or down until the TDS standard produces the desired TDS reading. The same is true for Salinity if you're using a standard qualified on the Practical Salinity Scale (PSS). "Enable" TDS and/or Salinity by checking the box next to those parameters in the "Sensors and Parameters" section.

5.10.4 PH



pH is measured as the voltage drop across the glass membrane of a pH electrode. A reference electrode is used to complete the voltage measuring circuit. The pH glass is specially formulated to absorb water so that ions (particularly H⁺ and OH⁻) in the water are attracted to the glass to offset the ionic constituency of the pH electrode's internal electrolyte.

As a result, there is a charge separation across the glass and that's the voltage we measure. pH readings are automatically compensated for temperature.

pH electrode maintenance is nothing more than occasionally cleaning the glass surface with a soft cloth and soapy water. Do not use anything abrasive. The really important part of pH maintenance is refilling the reference electrode.

You can choose a two or three-point pH calibration. The two-point calibration, a 7- buffer and a second buffer whose value is near that of the waters you intend to monitor, is recommended. If you are measuring in waters whose pH might range above and below seven, you can increase your accuracy slightly by choosing a three-point calibration (the third buffer should be on the other side of seven). pH calibration is simple:

- Rinse your sensors several times with the pH buffer you'll use for calibration.
- Fill the calibration cup with enough buffer to cover both the pH and reference electrodes.
- Follow the Control Software calibration instructions.
- Repeat steps 1, 2 and 3 if you choose to calibrate with one or two more standards

5.10.5 REFERENCE ELECTRODE

The key to reliable pH, ORP and ISE measurements is a well-maintained reference electrode. Recall that a reference electrode is required to complete voltage measurement for pH readings.

Reference electrode maintenance is simple:

- Remove the reference cap by unscrewing it from the reference sleeve and discard old reference electrolyte.
- Fill the sleeve completely with fresh pH reference electrolyte (KCl saturated with silver chloride). Tap the Proteus gently a few times to dislodge any bubbles.
- Screw the reference cap back on to the sleeve. As you screw the sleeve into place, air and excess electrolyte is forced out of the sleeve through the reference electrode junction (the white, porous circle at the end of the sleeve). This not only purges bubbles from the electrolyte, but also cleans nasty stuff out of the junction.



5.10.6 OI



ORP is measured as the voltage drop across the platinum membrane of an ORP electrode. The actual ORP sensor is the 1 mm silver-coloured dot you can see when looking down at the pH sensor – if your Proteus has ORP. A reference electrode is used to complete the voltage-measuring circuit. Because platinum does not react with ions in the water, it won't give or take any electrons from those ions unless they are very

persuasive. The potential (voltage) created by this refusal is what you're actually measuring as ORP.

ORP electrode maintenance is nothing more than occasionally cleaning the platinum surface with a soft cloth and soapy water. If the platinum is discoloured, you can polish the ORP electrode with very light abrasive, like 900-grit wet-and-dry sandpaper (please be careful not to polish the pH glass bulb). The important part of ORP maintenance is refilling the reference electrode. (D.9)

ORP uses a one-point calibration:

- Rinse your sensors several times with the ORP standard you'll use for calibration.
- Fill the calibration cup with enough ORP standard to cover both the ORP and reference electrodes.
- Follow the Software calibration instructions after selecting ORP_mV to calibrate.

5.10.7 DEPTH AND VENTED DEPTH (GAUGE)

Depth is measured by a strain-gauge transducer as hydrostatic water pressure. The deeper you go in the water, the higher the pressure.

Proteus depth sensors are usually inside the instrument, with a small pressure port that can be seen on the outside of the Proteus bottom cap. They require no regular maintenance, but you might check occasionally to make sure the pressure port is not clogged. If it is, use something soft, like a toothpick, to clear the port of obstruction.

Depth calibration is nothing more than "zeroing" the sensor in air, where one assumes the depth to be zero:

- Make sure the Proteus is not in the water.
- Follow the Control Software's calibration instructions.

Notice that the Depth sensor cannot distinguish between water pressure and the air pressure exerted on the water (i.e. barometric pressure). After you have zeroed the sensor, any change in barometric pressure will be measured as a change in water pressure. Water is considerably heavier than air so the error introduced by barometric pressure changes is small.

If increased accuracy is required the Vented Depth, or Gauge sensors are available. Vented Depth uses the same transducer as the Depth, except that there's a tiny hole in the back of the transducer. A vented cable is required, one with a small hollow tube running through it. Atmospheric pressure is sensed by the transducer via the little hole down the vent tube. Changes in barometric pressure will not affect the depth reading.

Vented-Depth cables have a desiccant-filled housing at their surface end. The desiccant keeps water from condensing in the vent tube by letting vapor escape through a small Gortex patch. Keep that housing clean and replace the desiccants every year or so when the colour change indicates so.

5.10.8 FLUOROMETERS

Chlorophyll, rhodamine, blue-green algae, tryptophan, CDOM, fluorescein and crude oil fluorometric sensors, are individually tuned to slightly different wavelengths.

Fluorescence occurs when a molecule absorbs light at one wavelength and then emits that energy at a different wavelength. More molecules of analyte produce a higher level of that different-wavelength light. Fluorometric sensors emit light at a certain wavelength and look for a very specific, different wavelength in return. The magnitude of the return light is relatable to the amount of analyte present.

Note that there are two types of blue-green algae sensors – fresh-water and marine.

Note that CDOM, or Coloured Dissolved Organic Matter, is also known as fDOM (fluorescent Dissolved Organic Matter), chromophoric dissolved organic matter, yellow substance and gelbstoff.

Note that there are many different types of crude oil and each has a relatively unique fluorescence response.

The maintenance procedure is similar for all fluorometers:

- Cleaning the sensor – Rinse the fluorometer in fresh water following each deployment, ideally until it is completely clean again. Do not let the chlorophyll sensor come in contact with any organic solvents, such as acetone and methanol, or strong acids and bases.
- Cleaning the optics – Visually inspect the optical window after each deployment following a soaking in fresh water. Use optical tissue to clean the window with soapy water, if needed.

5.10.9 ION-SELECTIVE ELECTRODES (ISE'S)



ISE's are traditionally used in the laboratory at a constant, moderate temperature, with ionic strength adjusters added to each sample so that the sample and calibration solution have roughly the same ionic strength. ISE's can provide valuable information in the field, for instance in watching short-term trends, but their calibration requirements, stability and accuracy are not nearly as simple and reliable as those for DO, conductivity, turbidity, etc. For field use, Proteus makes several theoretical and empirical corrections to elicit the best possible field performance.

ISE's operates much like a pH electrode except that the pH glass is replaced by a membrane that is selective for the analyte of interest (ammonium, chloride, nitrate, sodium). The electrode's filling solution contains a salt of the analyte and the difference between that salt's concentration and the analyte concentration in your water produces a charge separation. That charge separation is measured, relative to the reference electrode, as a voltage that changes predictably with changes in the analyte concentration in the water adjacent the membrane.

It's best not to let your ISE dry out, so place a small amount of tap water in the storage cup to ensure 100% humidity. The sensing elements (tip) for Nitrate and Ammonium ISE's have lifetimes of about 90 days. Then, you must replace the tip by unscrewing it from the sensor body and screwing in a new tip.

Each sensor body is programmed for a specific ISE; the ISE is identified by a series of rings or dots. One ring or dot means the sensor body is programmed for a Chloride ISE; two mean Calcium, three mean Nitrate, four mean Ammonium, five mean Bromide and six mean Sodium.

Note that the Ammonium ISE senses ammonium, but at pH's higher than about 8 the ammonium (NH_4^+) is mostly converted into ammonia gas (NH_3). Proteus's software uses the pH, Conductivity and Temperature of the sample water to calculate Ammonia (as mg/l-N). You can also display Total Ammonia; the sum of Ammonia and Ammonium.

Note that Ammonium and Nitrate ISE's suffer interference from positive ions, especially potassium and sodium and Sodium ISE's suffer interference from positive ions, especially potassium and ammonium. The Chloride ISE does not normally suffer from interfering ions.

Note that the Sodium ISE has a plastic membrane with a wider pH range (pH 3 – 10) and less pH interference than the traditional sodium ISE's (which are made with glass membranes). This sensor is specified to have a 10 second response time and a range of 0.05 – 2,300 mg/l Na+. The sodium ISE can be immersed to 15 meters of water without damage, but there may be a pressure effect on the reading. Although testing on a limited sample size showed this error to be within our $\pm 20\%$ accuracy specification, we recommend that users check the performance of their particular sensors under actual field conditions.

Note that the Sodium ISE has a slow response to changes in temperature and may take many minutes to reach a final reading when the temperature changes significantly.

If your Proteus is equipped with more than one ISE, use care when replacing tips so that you don't put a tip on the wrong sensor (for example put a Nitrate on the Sodium sensor).

5.10.10 TOTAL DISSOLVED GAS (TDG)



The TDG sensor is a pressure transducer (the same one used for the 10 meter depth sensor) attached to a "membrane". This membrane is a long piece of thin-wall, silicone tubing whose job is matching gas partial pressures inside the tube with those of the surrounding water. The sum of those partial pressures is measured by the transducer to give the TDG of the water.

Aside from keeping the membrane as clean as possible without tearing the tubing, the TDG sensor requires no maintenance. When the membrane is torn or is just too dirty, the membrane assembly must be replaced. Simply unscrew the old membrane and screw on a new membrane. Screw it on finger-tight, plus 1/4 turn.

Silicone rubber is chosen for the membrane material because gases pass through silicone readily. This means that response time for silicone is much faster than if the membrane were, say, Teflon. However, if the membrane is soaked in water for more than a few hours, the silicone absorbs just enough water to slow the gas transfer considerably. This is not usually a problem for unattended monitoring applications (the TDG doesn't change very quickly) but can be annoying if you are doing daily spot-checks. In that case, it's best to dry out the membrane between stations by using only a few drops of water in the storage cup instead of a full cup.

5.10.11 PAR (PHOTOSYNTHETICALLY ACTIVE RADIATION)

The PAR (photosynthetically active radiation) sensor measures the amount of light available to biota for photosynthesis. It's units of measurement are micro-moles of photons per square meter per second, or photon $\mu\text{moles}/\text{m}^2$ second. This is also referred to as micro-Einsteins per square meter per second.

The sensor looks like a light bulb and receives light from all directions except the "blind spot" at its base. Proteus mounts the PAR sensor a few inches away from the multiprobe, facing away from the multiprobe, so that the multiprobe is in the blind spot.

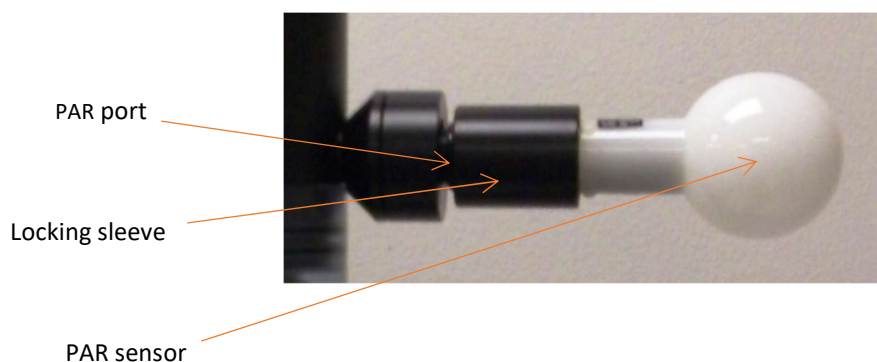


PAR sensors are supplied with a dummy plug so that you can use the Proteus without the PAR sensor attached.

PAR measurement is accessed for display through the menu structure just like all other sensors. The PAR sensor is calibrated at the factory and cannot be calibrated by the user. We recommend that the sensor be returned every couple of years to be re-calibrated.

PAR sensors are not attached to the multiprobe when shipped; there is a dummy plug in the PAR port. To attach the PAR sensor, simply unscrew the dummy plug's locking sleeve (it's the same type locking sleeve used for Proteus cables) and pull the dummy plug out of the port. Slide the locking sleeve onto the non-light-bulb end of the PAR sensor and push the PAR sensor into the port as you tighten the locking sleeve.

This may take a little bit of practice, as the locking sleeve's off-centre hole has to shift slightly to centre of the PAR sensor and its port.



There is no need to tighten the locking sleeve more than finger-tight.

Reverse the process to remove the PAR sensor if you wish to make calibration easier, or for cleaning, or for storage if you want extra protection for the PAR sensor. Simply unscrew the locking sleeve, pull the sensor away from the multiprobe, re-install the dummy plug and re-install the locking sleeve. The dummy plug seals the PAR port, so you can submerge the multiprobe without the PAR sensor attached.

The PAR sensor is made of acrylic plastic for optical reasons. Acrylic is somewhat brittle, so handle with care. It's also rather soft so clean the sensor only with soapy water and a soft wet cloth.

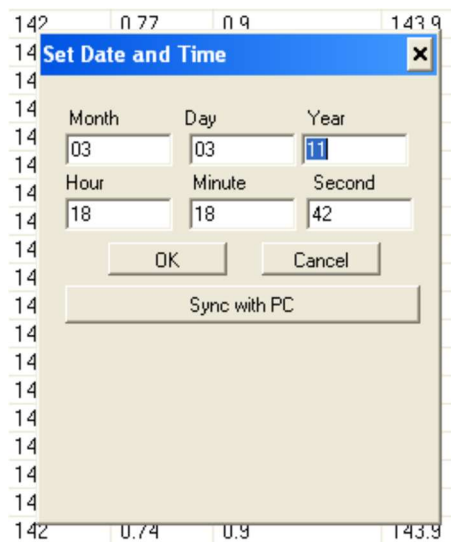
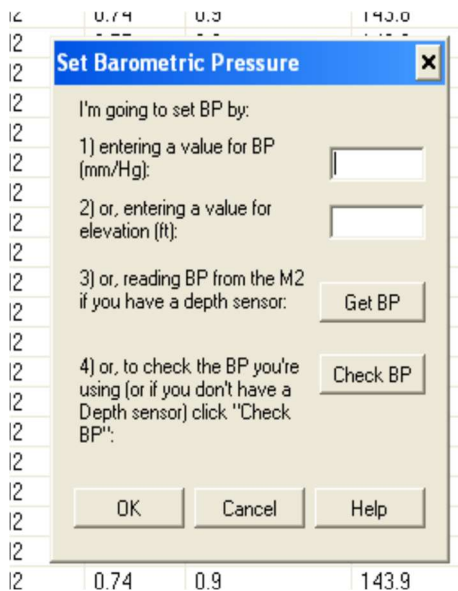
A copy of the manufacturer's PAR instruction manual is included with the PAR sensor, please take time to review this manual.

5.10.12 SET BAROMETRIC PRESSURE AND SET TIME AND DATE

Your Proteus needs to know the local Barometric Pressure (BP) if you have a Clark or Optical Dissolved Oxygen sensor, so click on the *Set Barometric Pressure* button (it's in the Calibrate menu). You can set the BP by typing the correct value (in mm Hg) in the first box of the Set BP screen (below, left). Or, you can set a less accurate figure and approximate BP by typing your altitude above sea level (in feet) in the second box. Notice that if you type in BP, altitude is automatically calculated and vice-versa. The third method for setting BP is asking your Proteus the value (if your Proteus is equipped with an un-vented depth sensor). If you choose this method,

remove the calibration cup from the Proteus and make sure the depth sensor is exposed to air. The correct values will automatically appear in the BP and altitude boxes.

Click on the Set Time and Date button to see the Proteus' opinion on time and date. If you wish to change any of those values, just type the new value in the appropriate box or click the box at the bottom of the screen (above, right) to synchronize the Proteus time and date with that of the device you're using to read the Proteus, i.e. your PC or Amphibian.



6 COMMUNICATION AND DATA LOGGING

When unattended data capture is required the *snapshot* function is not suitable as it requires a hard wired connection to a laptop or desktop computer. To overcome this problem the Proteus has a number of logging and telemetry options

6.1 INTERNAL DATA LOGGING

To enable internal datalogging on the Proteus the *ON/OFF* switch plate must be moved to the *ON* position. The LED indicator lights will confirm that logging is enabled and that sufficient voltage remains in the batteries. Synchronization of logging time is standard for the Proteus. For instance, if the logging interval is 15 minutes and the logging function is activated at 10:05, the first record will be 10:15 and then every 15 minutes thereafter. **NB.** For more detailed information on managing data logging refer to **Section 3**:

Before you go to the field to deploy your Proteus for unattended logging, always turn logging *ON* using the logging Hot Button on the Control Software. Flip the *ON/OFF* switch plate to *ON*. Logging will start and continue until you disconnect external power or flip the switch plate to *OFF*.

Logging interval, the time between logging runs in your Proteus, is set with the *Logging Setup* menu under the *Proteus* pull-down menu in the Proteus Control Software.

6.2 INTERNAL & EXTERNAL BATTERY PACKS

Most users log data will use an Internal Battery Pack (IBP) or External Battery Pack (EBP) but you can also log using power from a secondary power source (such as a solar-recharged storage battery located above the water surface) via the Underwater Cable. If you have an IBP or EBP and a secondary power source attached, the Proteus will use power coming from the secondary power source as long as its voltage is sufficient. If the Proteus cannot find adequate voltage in the Underwater Cable, it will use the IBP or EBP.

6.2.1 BATTERIES AND BATTERY LIFE

When the batteries in a Proteus battery pack are spent, logging simply ceases. It may begin again after a few hours if your batteries recover sufficiently during that time.

Unfortunately, there are so many different combinations of sensors, water temperature, Logging Intervals, types of batteries, etc. that estimation of battery life may not be very accurate. We recommend that you run the Proteus in the field to see how long the batteries will last in your specific application.

We recommend using the highest quality alkaline batteries available, such as Duracell Industrial. Rechargeable batteries can be used, but their battery life is typically only half that of non-rechargeable batteries.

It's a good idea to remove the batteries from the Proteus battery pack if the Proteus is not going to be used for a while. This helps prevent battery leakage.

Take all necessary precautions when using, installing and disposing of batteries.

6.2.2 CHANGING IBP BATTERIES AND ACTIVATING LOGGING

- Replace all batteries at the same time and use the same brand of battery.

- Clean all moisture, dirt, grit and any other debris off the Proteus because you are going to expose sealing surfaces as you change the batteries.



- Grasp the polymer “eyebolt” on the top of the battery housing and unscrew it until the top cap and clear housing detach from the Proteus body.
- Remove the spent batteries and install eight C-cell batteries (or six D-cell batteries) carefully following the polarity diagram.
- Clean all moisture, dirt, grit and any other debris off the exposed O-ring surfaces and the inside of the battery sleeve. Add a small amount of silicone grease to the O-rings and to the inside of the battery sleeve where the O-rings will seat.
- Carefully place the top cap – clear housing back into place and screw the eyebolt until the clear housing seats on the Proteus. You don’t have to tighten it closely to the IBP body; finger-tight is fine.
- Remember that you must first activate Proteus Logging by clicking the “Proteus Logging is OFF” Hot Button so that it changes to “Proteus Logging is ON”. (C.3, E.5)
- Remember to look for the red LED to blink five times to confirm that Logging is activated and the green LED blink briefly to confirm that the Proteus is receiving adequate voltage to start Logging.

6.2.3 LOGGING WITH AN EXTERNAL BATTERY PACK

6.2.3.1 THE EXTERNAL BATTERY PACK

All Proteus models can utilize the optional External Battery Pack, a watertight housing with a cassette for batteries that can be removed from the Proteus. Most EBP’s are used when logging, but they can also be used to power the Proteus while it is connected to a Data Display if the Data Display cannot provide sufficient power.

The EBP simply screws into the Proteus multiprobe where normally you would find the Underwater Cable and its locking sleeve. The EBP is installed immediately before a Logging deployment and later removed so your Proteus can upload data to a Data Display or be calibrated.

6.2.3.2 CHANGING EBP BATTERIES AND ACTIVATING LOGGING

- Replace all batteries at the same time and use the same brand of battery.
- Clean all moisture, dirt, grit and any other debris off the Proteus because you are going to expose sealing surfaces as you change the batteries.

- Unscrew the black knob at the top of the EBP it until the battery sleeve detaches from the EBP body
- Remove the spent batteries and install eight C-cell batteries (or six D-cell batteries) carefully following the polarity diagram.
- Clean all moisture, dirt, grit and any other debris off the exposed O-ring surfaces and the inside of the battery sleeve. Add a small amount of silicone grease to the O-rings and to the inside of the battery sleeve where the O-rings will seat.
- Carefully screw the battery sleeve back into place. You don't have to tighten it closely to the EBP body; finger-tight is fine.
- Remember that you must first activate Proteus Logging by clicking the "Proteus Logging is OFF" Hot Button so that it changes to "Proteus Logging is ON".
- Remember to look for the red LED to blink five times to confirm that Logging is activated and the green LED blink briefly to confirm that the Proteus is receiving adequate voltage to start Logging.

6.2.3.3 INSTALLING AND REMOVING THE EBP

- Remove the marine connector protector or, if a cable is attached to your Proteus, remove the locking sleeve and then the cable.
- Clean the connectors on the EBP and Proteus and add a little silicone grease to each.
- Find the white dot on the hexagonal sleeve on the bottom of the EBP and note that the Proteus connector has six pins with a gap in the outer circle of pins.
- Line up the white dot with the gap in the connector pins and slowly push them together. Very little force is needed.



- Grasping only the Proteus and EBP locking sleeve (the portion of the lower EPB with the serrations), turn the EBP locking sleeve so that it screws into the threads where the Underwater Cable locking sleeve is normally fitted. You may have to jiggle the EBP a bit so that the hexagonal sleeve fits properly over the hexagonal base of the connector.
- Tighten the EBP locking sleeve firmly, but not so tightly that you will have difficulty removing it later.
- Remember that you must first activate Proteus Logging by clicking the "Proteus Logging is OFF" Hot Button so that it changes to "Proteus Logging is ON".
- Remember to look for the red LED to blink five times to confirm that Logging is activated and the green LED blink briefly to confirm that the Proteus is receiving adequate voltage to start Logging.

Your Proteus is now logging and will continue logging until you remove the EBP, or your batteries are depleted.

To remove the EBP, grasp the Proteus with one hand and the EBP locking sleeve with the other and unscrew the EBP locking sleeve. Pull the Proteus and EBP apart.

6.3 DIRECT CONNECTION

For certain applications (e.g. laboratory experiments or aquarium monitoring) it may be feasible to connect directly to a desktop/laptop computer for extended periods. In these instances the data is logged directly to the hard drive of the computer as outlined in Section 3

For connecting with an Amphibian PDA follow the procedure that follows:

- Power-on the Amphibian Data Display.
- Connect the Proteus and Underwater Cable to the Amphibian using the nine-pin connector on the bottom end of the Amphibian2.
- On the lower right corner of the start-up screen, select “Amp_2_2_X or Proteus_2_2_X” to launch the Proteus control software.
- You should see scrolling data from the Proteus.

6.4 BLUETOOTH

A Bluetooth module can also be used to communicate wirelessly between the Proteus and computer/PDA.

6.4.1 BLUETOOTH BATTERY

The Amphibian connects directly to a Proteus via a Data Cable or Underwater Cable. But smart phones and tablets seldom have conventional USB ports, so we connect to them using Bluetooth.

The Bluetooth Battery contains a Bluetooth transmitter and receiver, an on/off switch and a rechargeable battery sized to get you through a full day of field work.

The Bluetooth Battery’s Bluetooth address is shown on a label.

6.4.2 ESTABLISHING BLUETOOTH COMMUNICATION

Follow the directions below for establishing Bluetooth communication between your Bluetooth Battery and Data Display.

For connecting the Amphibian using Bluetooth for the first time follow procedure below:

- Power-on the Amphibian Data Display.
- Turn on the Proteus Bluetooth Battery by pushing the on/off button. You will see the LED begin flashing indicating that the unit is “ON” (if not, recharge the battery using the charger provided).
- Enable Bluetooth (BT) on the Amphibian by pushing the BT ICON on the start-up screen. Make sure the BT ICON turns green and says “Discoverable”.
- On the Amphibian Home Page select “Settings”, then “Connections” and then select the “Bluetooth” ICON (not the BT COM ICON). Delete any BT devices listed by pressing and holding, then select delete.
- Select “Add New Device”, select the Bluetooth ID of your Proteus BT when it appears, then select “Next”.
- Enter the password “1234” and select “Next” and the display will connect to your Proteus BT. Select the Proteus BT device and put a checkmark on the serial port and then select “Save”.
- Now select “COM Ports” at the top of the screen. Next select “New Outgoing Port”, then your Proteus BT will show up highlighted. Select “Next” from the bottom and use the pull-down menu to select an available COM port, such as COM5. Once selected, select “Finish” and then “OK”. Select “X” to return to Home Page.

- On the Home Page, select “Amp_2_2_X” to launch the Proteus control software. Upon connection, the blinking light on the Proteus BT will turn solid. Once the software is running and the Amphibian is connected via the Proteus BT, you should see data scrolling.
- From now on when the Amphibian is on, with Bluetooth enabled and the Proteus BT Battery is switched “ON”, the Proteus will be found on the previously-selected COM port, unless you change the settings.

6.4.3 CONNECT TO “CLASSIC BBLUETOOTH” ANDROID DATA DISPLAYS

- Install the Classic Bluetooth version of the software.
- Power up the Bluetooth Battery by pressing the on/off button.
- For the initial pairing of the BT module to the Data Display, go to “MORE” (Smartphone), or “:” (tablet) and select “Android”, “Scan Filter”. Clear any settings in field, Select “OK”
- Go to the “Bluetooth SETTINGS” on the Data Display and select the Bluetooth ID of your Proteus Bluetooth Battery. The device IDs for Classic Bluetooth have normally had the format “Proteusxxx” or “ProteusEDRXXXX”. Do not select the address with format ProteusBLExxx for Classic Bluetooth utilities, as the hardware and firmware of Low Energy Bluetooth (discussed below) is NOT compatible with Classic Bluetooth and will interfere with making this device connection.
- Enter the password “1234”.

Once the password is accepted, the devices are paired and you should now see scrolling data.

6.5 EXTERNAL DATA LOGGERS AND RTU’S

6.5.1 SDI-12 ADAPTOR KIT

When interfacing with external data loggers and RTUs the output from the Proteus can be easily converted from R232 to SDI 12 using an SDI 12/TTL converter (Figure 22: Proteus SDI12 Adaptor Kit).

NB SDI-12 (serial data interface at 1200 baud) is a communication protocol peculiar to environmental monitoring. In theory, any SDI-12 sensors (including multiprobes) can transfer data upon request to any SDI-12 controller (such as a data logger or telemetry system). The protocol follows a master-slave configuration whereby a data logger (SDI-12 recorder) requests data from the intelligent sensors (SDI-12 sensors), each identified with a unique address.

When you power-up your SDI-12 controller, it supplies power to the Proteus and reads the sensor configuration. This is how the controller knows how to parse and label the data coming from the Proteus2 and how much delay to allow before requesting measurements.

The Proteus SDI-12 Adapter (Fig 19) has one male D-Sub-9 connector that mates to the Proteus2 through your PC’s Serial Adapter Cable and a 3-wire SDI-12 pigtail to connect to your SDI-12 controller.



Figure 22: Proteus SDI12 Adaptor Kit

6.5.2 CHANGING THE PROTEUS SDI-12 AADAPTER’S ADDRESS

The default address is “0” for the Proteus SDI-12 Adapter. The SDI-12 standard allows for addresses 0 through 9, for up to ten devices connected to the same SDI-12 host (via the 3-wire connections). You can change the SDI-12 Adapter’s SDI-12 address using the 4-position dipswitch on the circuit board, as shown in the picture below. The picture shows the default SDI-12 address of “0”, where all of the switches are in the OFF position (the position away from the word “ON” printed on the switch).

Table xx. switch positions to change the address of the SDI-12 adaptor:

Address	Switch position			
	1	2	3	4
0	-	-	-	-
1	-	-	-	ON
2	-	-	ON	-
3	-	-	ON	ON
4	-	ON	-	-
5	-	ON	-	ON
6	-	ON	ON	-
7	-	ON	ON	ON
8	ON	-	-	-
9	ON	-	-	ON

NB all other combinations will set the address as “0”

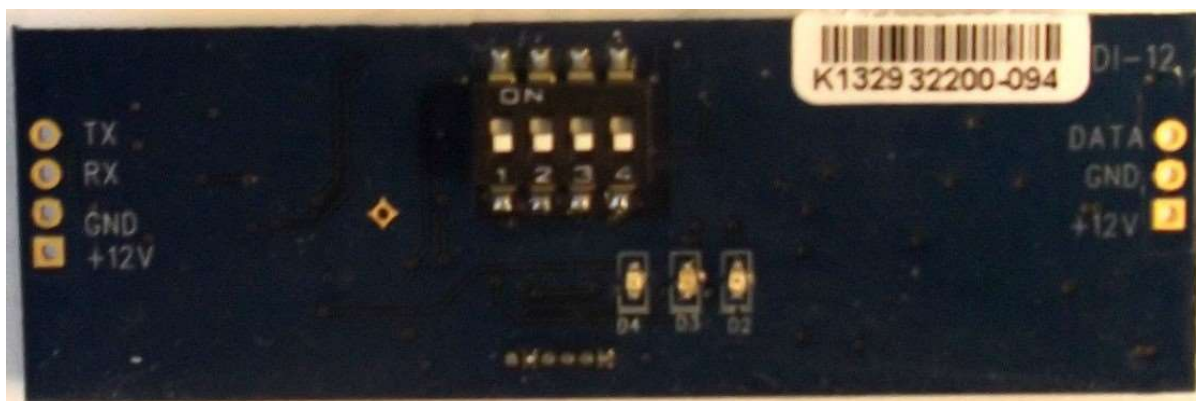


Figure 20. Dipswitch on SDI-12 convertor

6.5.3 CONNECTING THE SDI-12 ADAPTER TO YOUR CONTROLLER

By controller we mean data logger, PLC, RTU:

- a) connect the multiprobe to the SDI-12 Adapter; then,
- b) connect the SDI-12 Adapter's three 3 wires to your controller as follows:
 - red – power (~+6 VDC to +12 VDC) black –
 - ground green – SDI-12 (data)
- c) Once you power-up your SDI-12 controller, you are ready to take data according to the configuration you set for the controller.

6.5.4 BASIC SDI-12 COMMANDS

Proteus Instruments have implemented all basic SDI-12 commands (see below) and selected extended commands.

The most common sequence of commands issued (assuming address "0") is:

- 0! (verify communication with the device on address 0)
- 0M! (start a measurement on device with address 0)
- 0D0! (return the first set of measurements)
- 0D1! (return the next set of measurements, if necessary)

Step (2) will return a value such as "00346", which is interpreted as follows:

- The first "0" is just echoing the address "0", the address of the device that responds.
- "34" indicates the number of seconds to wait before issuing the 0D0! command, which will retrieve the measurements.

- “6” indicates that 6 parameters will be returned. Note that all parameter might not fit into the data stream all at once, so that subsequent 0Dx! commands may have to be issued to obtain the remaining parameter data, where “x” is a value from “0” to “9”.

NB The Proteus cannot be configured or calibrated via the SDI-12 adapter.

7 MAINTENANCE

For cleaning main body and sensors use warm water mixed with mild detergent and a soft bristled brush. Do not use industrial cleaners, acetone or abrasives. Rinse well with deionized water if this is not available then tap water will suffice.

7.1 TURBIDITY SENSOR AND WIPER ARM

Turbidity sensors require no regular maintenance as the sensor has an automatic wiper for cleaning. However, regular checks are recommended to ensure the optical window (small glass port on the sensor face) has not been damaged.

The turbidity sensor is supplied with a wiper, however this can deteriorate over time or can clog with debris (algae, silt, etc.). The wiper is also supplied with an extended brush arm for cleaning the window of the tryptophan like fluorometer. To change the wiper pad:

- DO NOT MANUALLY FORCE ROTATE THE WIPER ARM
- Make sure you have the 1.5mm hex key and a new pad for the wiper. Loosen the small set screw on the wiper arm.



Figure 21.(a) Location of set screw for removing the wiper (b) brush arm with wiper pad and brush highlighted

- Remove the wiper pad from the wiper arm and replace the pad.
- Place a new wiper arm on the motor shaft so that the set screw faces the flat spot on the motor shaft.
- Gently press the wiper pad against the face of the probe until the pad is compressed to roughly three quarters of its original thickness. It is important that the wiper arm does not make contact with the probe face – only the pad should be in contact. A gap of 0.5 mm between the wiper arm and the probe face is typical when a new pad has been installed. Another way of setting the pad gap is to place the pad such that you can slide a small piece of paper under the pad, but snug enough that the pad will hold the paper.
- Tighten the set screw.
- Use the first Allen wrench from your wiper kit to remove the standard turbidity sensor wiper. Use the other Allen wrench to install the brush arm. Notice that the Allen set screw seats on the flat side of the wiper motor shaft.

7.2 TRYPTOPHAN FLUOROMETER

The fluorometer should be rinsed or soaked in fresh (deionized if available) water following each deployment, ideally until it is completely clean again. The optical window should be visually inspected after each deployment following a soaking in fresh water. If cleaning is needed, use optical tissue to clean the window with soapy water, then rinse thoroughly with deionized water.

*NB: The fluorometer should **NOT** come in contact with any organic solvents (i.e. acetone, methanol) or strong acids and bases.*

8 APPENDIX

8.1 TROUBLE SHOOTING:

8.1.1 COMMUNICATION WITH COMPUTER

- Check connection (cable to Proteus and USB converter).
- Check driver/software are properly installed.
- Break the connection, reconnect and restart the software.
- Check COM port on Proteus communication software matches the USB adaptor COM port.
- Is the green LED flashing – if not the sensor is not receiving sufficient voltage?
- If you have another cable or Proteus test communication using these.
- Make sure all internal connections are securely seated.

It is possible the CPU board needs to be replaced or repaired

8.1.2 MEASUREMENTS VALUES ARE NOT REALISTIC:

- Are all the sensors calibrated correctly
- Has regular maintenance of the sensors been carried out
- Are the units displayed correctly (e.g. °C or °F)
- Is there any obvious damage or water leaks
- For optical sensors (i.e. turbidity and fluorometer) ensure window is clean use lens cloth

8.2 FAQ

8.2.1 SENSORS

HOW DO I KNOW WHEN I NEED TO MAINTAIN SENSORS?

Judgment gained from observing your field conditions and data requirements tells you when to maintain sensors. If you are logging data over long periods, the time when you collect your data from the Proteus is a good time for maintenance and calibration.

WHY IS IT IMPORTANT TO CHECK SC READING IN AIR? WHAT SHOULD IT BE?

A well-dried SC sensor should produce a zero reading in air. This lets you know that a one-point calibration is adequate.

HOW DO I GET THE BAROMETRIC PRESSURE READING FOR THE DO CALIBRATION? DO I NEED TO CHECK IT TO A CERTIFIED BAROMETER?

You can enter an exact BP from your lab barometer or your weather station's BP if you correct for altitude or, you can enter your elevation and the Proteus will estimate your BP or, if your Proteus has a Depth sensor (non-vented gauge only), the Proteus can use it to measure BP.

HOW OFTEN SHOULD I CHANGE THE PH ELECTROLYTE?

Electrolyte usually lasts two months or more. But if you are logging data, or monitoring in very low Conductivity waters, change your electrolyte each time before you recalibrate pH to be safe. You may learn a better rule of thumb as you review your data.

HOW OFTEN SHOULD I CHANGE MY TURBIDITY WIPERS?

Wipers usually last for years, but you should change yours if it gets stiff or has nicks in it.

CAN I CUSTOMIZE THE PROTEUS WITH DIFFERENT CONFIGURATIONS OF SENSORS?

We can fit up to 12 sensors in just about any combination you need and custom parameters can be set as per 3.4.2.

HOW LONG DO ISE TIPS LAST?

The usual rule is six months, but you may get more or less than that. Change tips often to be safe, but you may learn a better rule of thumb as you review your data.

8.2.2 CALIBRATION AND MAINTENANCE

HOW DO I KNOW WHEN I NEED TO CALIBRATE MY SENSORS?

The simple answer is that frequent calibration will give you better data. The more meticulous you are with calibration, the better data you will gather. If you are uncertain whether you need to calibrate, check your sensors against a known sample. If the reading is within the accuracy specification and/or your accuracy expectations, there is no need to calibrate.

Experience and your program's accuracy expectations will help determine calibration frequency for the various sensors. If, for instance, your reservoir discharge is hovering near the regulatory minimum for dissolved oxygen, you should pay special attention to DO calibration frequency and technique. On the other hand, if a conductivity accuracy of +/- 10% is OK, you needn't calibrate conductivity very often.

HOW OFTEN SHOULD YOU CALIBRATE YOUR MULTIPROBE?

That depends on a number of factors, including the nature of the waters being monitored and your expectations for accuracy. We suggest that you start by calibrating once per week and shorten or lengthen that interval as confidence levels change.

HOW DO I CHOOSE CALIBRATION STANDARDS?

For best results, choose a calibration standard whose value is close to what you expect to see in the field. For example, calibrate with a 1413 μS Specific Conductance standard if you expect to see Specific Conductances between 500 and 1000 μS in the field. Don't calibrate with a sea water standard. And if your waters tend toward the acidic, calibrate with a 4-buffer instead of a 10-buffer.

If you are moving your multiprobe across wide ranges of water conditions, you may wish to recalibrate to match the new situations. For instance, if you are measuring a clear lake during the morning and a high-sediment stream in the afternoon, you might consider recalibrating at noon with a high-range turbidity standard.

WHAT IS AN SRF?

Suppose that a typical Conductivity sensor reports 100 μA in a 1413 $\mu\text{S}/\text{cm}$ standard. If your particular Conductivity sensor reports 100 μA in that same calibration solution, then your SRF is 100% (some parameters, such as pH, have a more complex SRF calculation, but the effect is the same). If your response is 80 μA , your SRF would be 80%. When you click the OK button to accept a calibration, the Proteus automatically accepts your calibration if the SRF is between 60% and 140%. If the SRF falls outside that range, you will be cautioned to check your standard value, make sure the sensor is clean, make sure the reading has stabilized, etc. But you can elect to accept any SRF.

Each sensor calibration's Sensor Response Factor (SRF) is automatically logged into the Cal Record with the details of that calibration.

WHAT IS THE BASIC CALIBRATION PROCEDURE?

The Proteus never guesses parameter values, so you have to calibrate it from time to time by simply telling the instrument what it should read in a known calibration situation. The general procedure is shown below.

1. Pay attention to and respect regulatory and legal requirements regarding the safe handling and disposal of calibration fluids, batteries and all materials you or the Proteus may come into contact with.
2. Clean the sensor and perform any necessary sensor-specific maintenance.
3. Select a calibration standard whose value is close to the values you expect to see in the field.
4. Rinse sensors thoroughly (more than once may be required) with DI (deionized) water, especially if you have been using other calibration solutions. Shake the Proteus so the DI can vigorously remove traces of old calibration solutions and cleaning agents – repeat if necessary.
5. Rinse the sensors twice with a small quantity of your calibration standard. Discard the used calibration standard to prevent contamination with DI water.
6. Immerse the sensor in the calibration standard. This is usually accomplished by securing your Proteus with the sensors pointing up, screwing the Cup onto the Proteus and filling the Cup with your calibration standard. Make sure the standard covers the sensor entirely and that it also covers the thermistor for those parameters that are temperature-compensated.
7. Watch the parameter readings until they have stabilized.
8. Select the parameter to be calibrated by clicking on the Calibrations button in the Proteus Manager Home Screen, then clicking on Calibrate and then clicking on the parameter you wish to calibrate. For

Parameters that have two calibration points, you will specify which you wish to calibrate (usually High or Low). Enter the calibration value and click on OK. The Proteus will report the resulting Sensor Response Factor (SRF); then click on OK to accept the calibration or Quit to leave the sensor uncalibrated.

9. Each sensor calibration's Sensor Response Factor (SRF) is automatically logged into the Cal Record with the details of that calibration.

CAN I USE CALIBRATION SOLUTIONS MORE THAN ONCE?

It is good practice to use fresh calibration solutions for every calibration. If not, then your sensitivity to cost and accuracy will determine whether you can re-use calibration solutions. If, for instance, you really want your field conductivity readings to be within 1% of reading, then fresh conductivity calibration solution which is relatively low cost should be used for each calibration. If turbidity accuracy is not critical you could consider reusing your turbidity cal solution.

WHAT STANDARD SHOULD I USE TO CALIBRATE SC? WHAT TYPE?

For any parameter, use a calibration standard that is near the highest reading you anticipate in the field. For instance, if your lake usually runs about 1000 $\mu\text{S}/\text{cm}$, then calibrate with the readily available 1413 $\mu\text{S}/\text{cm}$ KCl standard. Note that some sensors (not SC) have two calibration points; the second point should be set at a convenient low point, usually zero.

WHAT IS THE DIFFERENT BETWEEN CALIBRATING % SAT OR MILLIGRAMS PER LITRE FOR DO?

Percent saturation tells you how much oxygen you have compared to how much you would have if the water were saturated with oxygen. Milligrams per litre tells you just that: how many milligrams of oxygen are dissolved in one litre of water. For instance, if your Proteus was reading 6.0 mg/l and the saturation tables told you that at that temperature, salinity and barometric pressure the saturation value was 8.0 mg/l, then your % sat would be $6/8 = 75\%$. You can use either measurement, or both, but % sat is helpful during DO calibration because it should always be 100%.

WHAT IS THE DIFFERENT BETWEEN THE AMCO CLEAR TURBIDLY STANDARD AND STABLCAL?

Amoco Clear is made of polymer beads while StablCal is a formazin compound. Most people want their turbidity measurements referenced to formazin and so use formazin or StablCal for calibrations. The polymer beads are cheaper and more stable, BUT you must know the equivalent formazin value for any polymer bead standard. You cannot rely on what's written on the polymer-bead label; you must check it with your own instrument after it has been calibrated with formazin or StablCal.

WHAT IS A GOOD SRF?

Generally and SRF between 80 and 120 is good and 60 to 140 is acceptable. If your SRF is outside those limits, you should check your standard value and the maintenance condition of your sensor.

HOW OFTEN SHOULD I CHANGE THE PH ELECTROLYTE?

To be safe, change your electrolyte every month or so. That's probably overkill, but changing electrolyte takes only a minute and is basically free.

8.2.3 COMMUNICATION AND SOFTWARE

WHAT IS THE RANGE OF THE BLUETOOTH?

Hard to say because of the differences in Bluetooth technology over the years, variations in Data Display Bluetooth implementations and because Bluetooth is different for Android and Apple applications. You can estimate Bluetooth range of your Bluetooth by connecting your Proteus to your Bluetooth Battery, pairing with a Data Display and then walking away with the Data Display until the connection breaks.

HOW LONG DOES THE BLUETOOTH BATTERY TAKE TO CHARGE?

We recommend charging overnight, but you can get a partial charge in an hour or two.

IS THE COLORED TOP LINE AN AVERAGE OF THE VALUES OR THE LATEST READINGS?

No; the data in the coloured band is the most recent line of data obtained from your Proteus.

8.2.4 DEPLOYMENT AND APPLICATIONS

HOW LONG CAN I EXPECT MY BATTERIES TO LAST?

Battery life is difficult to predict because it varies with Logging Interval, quality of batteries, number and type of sensors and water temperature. Battery life can be optimised by experimenting with different battery types for your specific Proteus in your applications.

FOR MY BATTERY PACK WHEN LOOKING IN THE LOG FILE AT BATTERY VOLTAGE, AT WHAT POINT WILL THE PROTEUS STOP LOGGING?

The Proteus can show the voltage provided via the cable and the voltage provided by an Internal Battery Pack. The voltage provided by an External Battery Pack is shown as cable voltage. There is no fixed cut-off point, but any time the battery pack or cable voltage drops below about 5 VDC, the voltage may not be adequate for the Proteus to boot properly.

WHAT HOW DO I DEPLOY MY SONDE WHEN THERE IS NO BAIL HOOK? IS IT OK TO HANG BY THE CABLE? HOW MUCH WEIGHT WILL THE CABLE HOLD?

When properly attached, the Proteus Underwater Cable can support 20kg without using a Bail Kit. You can hang the Proteus by the Underwater Cable if the load is not likely to exceed 20kg.

CAN I ADD SENSORS TO MY PROTEUS?

The Proteus can handle as many as 12 sensors. If you have fewer than 12 then it may be possible to add more sensors depending on the current configuration.

8.2.5 SDI-12 COMMANDS (VERSION 1.3)

Name	Command	Response	
Break	Continuous spacing for at least 12 ms	None	
Acknowledge active	a!	a<CR><LF>	
Send identification	a!	allccccccmmmmmmvvvxxx...xx<CR><LF>	
Change address	aAb!	b<CR><LF> (support for this command is required only if the sensor supports software changeable addresses)	
Address query	?!	a<CR><LF>	
Start measurement	aM!	atttn<CR><LF>	
Start measurement and request CRC	aMC!	atttn<CR><LF>	
Send data	aD0!	a<values><CR><LF> a<values><CRC><CR><LF>	or
	.	a<values><CR><LF> a<values><CRC><CR><LF>	or
	.	a<values><CR><LF> a<values><CRC><CR><LF>	or
	.	a<values><CR><LF> a<values><CRC><CR><LF>	or
	aD9!	a<values><CR><LF> a<values><CRC><CR><LF>	or
Additional measurements	aM1!	atttn<CR><LF>	
	.	atttn<CR><LF>	
	.	atttn<CR><LF>	
	.	atttn<CR><LF>	
	aM9!	atttn<CR><LF>	
Additional measurements and request CRC	aMC1! ... aMC9!	atttn<CR><LF>	
Start verification	aV!	atttn<CR><LF>	
Start concurrent measurement	aC!	atttn<CR><LF>	
Start concurrent measurement and request CRC	aCC!	atttn<CR><LF>	

Additional concurrent measurements	aC1!	atttnn<CR><LF>
	.	atttnn<CR><LF>
	.	atttnn<CR><LF>
	.	atttnn<CR><LF>
	aC9!	atttnn<CR><LF>
Additional concurrent measurements and request CRC	aCC1!...aCC9!	atttnn<CR><LF>
Continuous measurements	aR0! ... aR9!	a<values><CR><LF> (formatted like the D
Continuous measurements and request CRC	RC0! ... aRC9!	a<values><CRC><CR><LF> (formatted like the D commands)