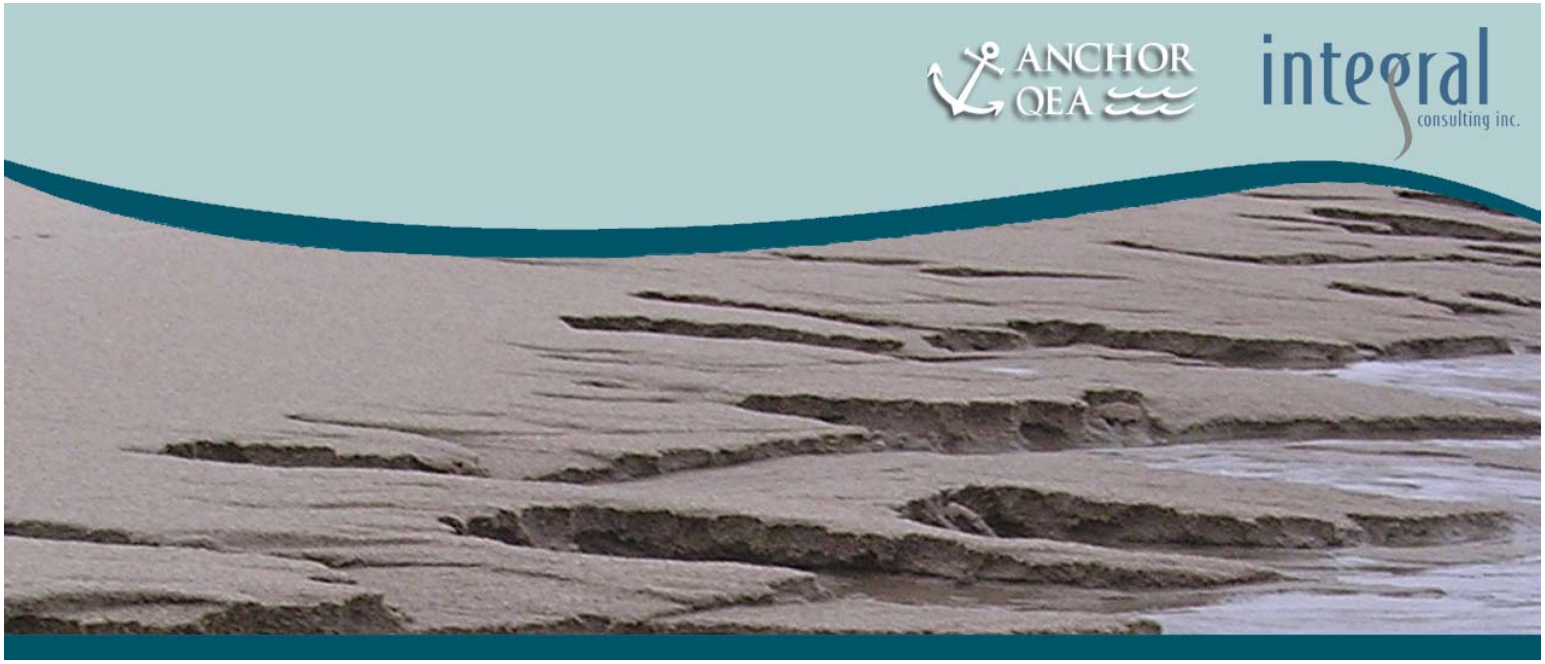

FINAL CURRENT VELOCITY STUDY
FIELD SAMPLING PLAN
SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation

International Paper Company

U.S. Environmental Protection Agency, Region 6

Prepared by

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May 2011

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FINAL CURRENT VELOCITY STUDY FIELD SAMPLING PLAN SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

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- CTD Quick Start Guide
- CTD User Manual
- WinH-ADCP User's Guide
- WinADCP User's Guide

Attachment 3 Survey Equipment Data Sheets

- Teledyne RD Instruments Workhorse Sentinel Self Contained 1200 kHz ADCP
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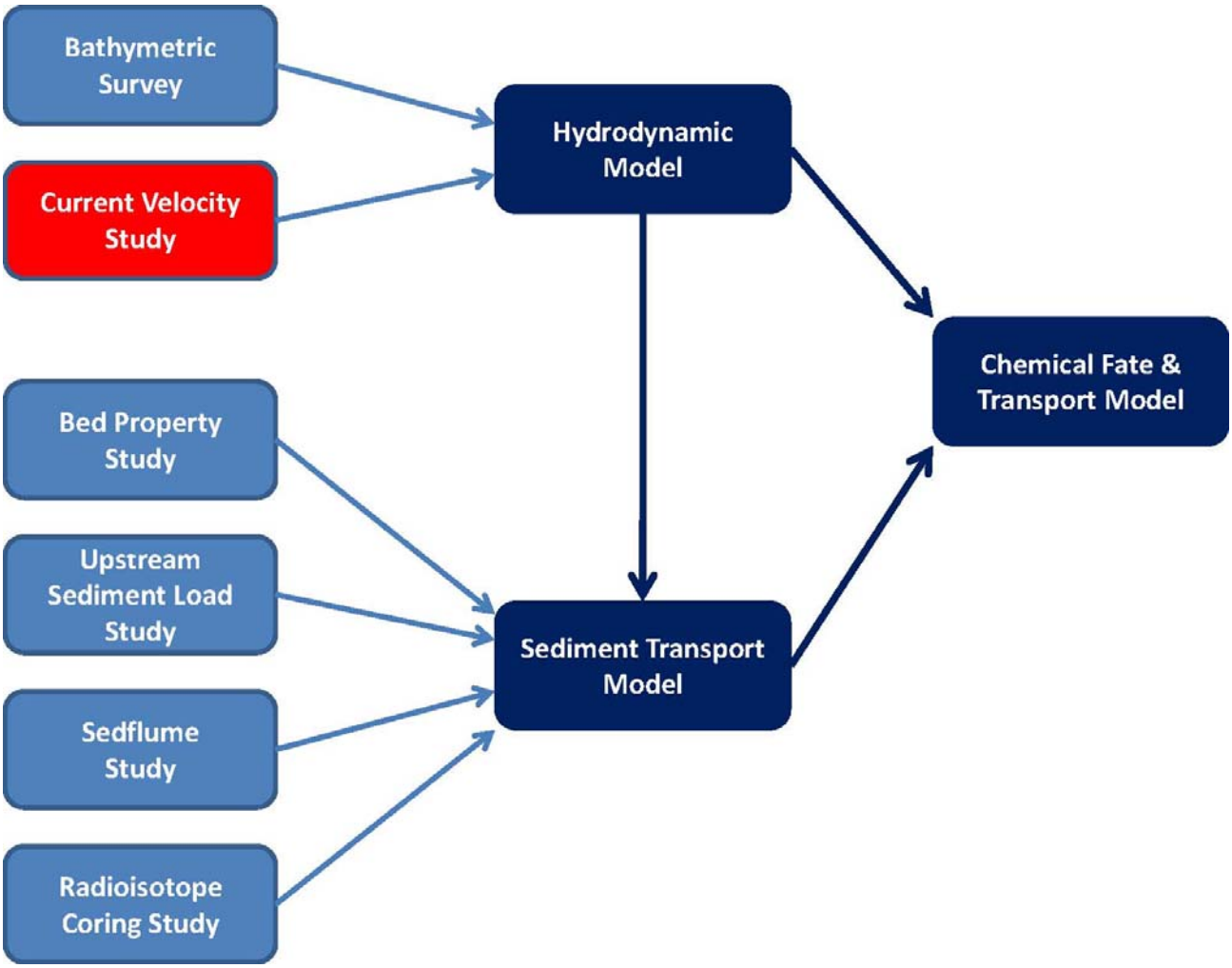
LIST OF ACRONYMS AND ABBREVIATIONS UPDATE

ADCP	Acoustic Doppler Current Profiler
Anchor QEA	Anchor QEA, LLC
CDT	Central Daylight Time
CFS	cubic feet per second
CTD	conductivity, temperature, and depth
DGPS	Differential Global Positioning System
FSP	Field Sampling Plan
GCS	Geographic Coordinate System
GMT	Greenwich Mean Time
HASP	Health and Safety Plan
Integral	Integral Consulting Inc.
MSL	mean sea level
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum 1988
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OSI	Ocean Surveys, Inc.
QA/QC	quality assurance/quality control
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SOP	Standard Operating Procedure
TCRA	Time Critical Removal Action
TPWD	Texas Parks and Wildlife Division
TSS	total suspended solids
UAO	Unilateral Administrative Order
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geologic Survey

1 INTRODUCTION

This document provides a Field Sampling Plan (FSP) for the current velocity study at the San Jacinto River Waste Pits (SJRWP) Superfund Site (the Site) located in Harris County, Texas (Figure 1). This FSP was prepared as a supplement to the Final Sampling and Analysis Plan Addendum Chemical Fate and Transport Modeling Study (Fate and Transport Addendum; Anchor QEA and Integral 2010b), which is an Addendum to the Sampling and Analysis Plan, Sediment Study (Sediment SAP; Integral and Anchor QEA 2010). The chemical fate and transport modeling study is required by the Remedial Investigation and Feasibility Study (RI/FS) Work Plan (Anchor QEA and Integral 2010a) and describes the sampling and fate and transport modeling efforts to be undertaken in support of achieving the overall RI/FS goals. Together with the Sediment SAP and the Fate and Transport Addendum, this FSP provides information on field activities and related documentation to meet the requirements of the U.S. Environmental Protection Agency (USEPA) guidance (USEPA 1988, 1992, 2001, and 2002) and as required by the Unilateral Administrative Order (UAO) (USEPA 2009). Additional information of the Site history and a summary of existing data are provided in the RI/FS Work Plan (Anchor QEA and Integral 2010a) and Sediment SAP (Integral and Anchor QEA 2010). Information on the geology, physiography, hydrology, and cultural and natural resources of the Site and information on fate and transport is provided in the RI/FS Work Plan (Anchor QEA and Integral 2010a).

Six field studies are being conducted to provide information and data for the chemical fate and transport modeling study: 1) bathymetric survey; 2) current velocity study; 3) bed property study; 4) upstream sediment load study; 5) Sedflume study; and 6) radioisotope coring study. The flow chart shown below illustrates the relationships between the field studies and the specific models for which each field study will provide data. The hydrodynamic model provides transport information (e.g., current velocity, water depth) to both the sediment transport and chemical fate and transport models. The sediment transport model provides erosion and deposition flux information to the chemical fate and transport model.



The objective of the current velocity study is to collect data (e.g., water surface elevation, current velocity, salinity) that will be used to calibrate the hydrodynamic model. The survey will be conducted concurrently during an upstream sediment load study (Anchor QEA and Integral Consulting, Inc., 2010b). The data will be used to:

- Confirm that a high-flow event has occurred during the sediment load study.
- Augment hydrodynamic data that has already been collected in July 2010 with details described in Appendix K of the TCRA Removal Action Work Plan (Anchor QEA, 2010b).
- Calibrate and validate the hydrodynamic model.

This FSP describes the equipment, procedures, and protocols that will be used to conduct the current velocity study, and to prepare the dataset for use in the hydrodynamic model and during the RI/FS in general.

1.1 Overview

For this study, an Acoustic Doppler Current Profiler (ADCP) and a conductivity, temperature, depth (CTD) sensor will be used to collect current velocity, water surface elevation and salinity data from a location within the Site. An ADCP uses a type of sonar technology that measures and records current velocities over a range of depths in the water column. An ADCP transmits sound bursts between 300 and 1200 kHz into the water column and suspended particles carried by water currents produce echoes (from these sound bursts). These echoes are "heard" by the ADCP with echoes from deeper in the water column arriving later being assigned greater depths in the echo record. This allows the ADCP to form vertical profiles of current velocity. The ADCP senses water movement in four orthogonal directions simultaneously, with particles within the current flow moving towards the instrument exhibiting different echo frequencies from those moving away. This process is known as the Doppler shift; assessment of this phenomenon by the ADCP enables the precise measurement of current speed and direction.

A complete primer on the operation and theory behind ADCPs can be found in Teledyne (2011). The primer indicates that there is an inverse relationship between the ADCP frequency and its range. For this particular study, the 1200 kHz frequency range will be used, which has a nominal range of 25 meters (m), and is applicable to the shallow waters of the San Jacinto River in the vicinity of the study area.

To achieve the objectives described above, Ocean Surveys, Inc. (OSI), based in Connecticut, will be contracted by Anchor QEA to deploy one ADCP equipped with a CTD sensor in the vicinity of the waste impoundments at a water depth of up to 20 feet (6 m). The ADCP will record data continuously and averaged into 6-minute intervals. The ADCP will be deployed for at least a one-month period and will be coincidently deployed with an automated sampler for the upstream sediment load study.

The ADCP will be located in a section of river proximal to both the impoundments, the various sampling locations of the upstream sediment load study and in a relatively protected area of the main river channel, while being representative of general flow conditions. This area was also selected because the sediment bed is relatively flat which is needed for proper operation of the ADCP. The ADCP will measure the magnitude and direction of currents throughout the water column (i.e., vertical velocity profile). A depth-averaged current velocity (magnitude and direction) will also be determined. In addition, the CTD will measure water depth (tidal elevation), temperature and salinity.

The hydrodynamic model will be calibrated and validated using current velocity data collected at two different locations during two different years (the previous 2010 study and the current 2011 study). These data will be sufficient to adequately calibrate and validate the model. The two ADCP deployments are similar in that current velocity data was or will be obtained over an approximate 2-month period. The 2010 ADCP location was placed relatively close to the waste impoundments because the original focus of that data collection effort was to support TCRA design activities. The 2011 ADCP location was chosen to obtain data that are representative of hydrodynamic conditions further away from the waste impoundments. The current velocity data collected during 2011 will be used to calibrate the hydrodynamic model, while the 2010 data will be used for model validation. Based on modeling experience at other sites, using tidal elevation and current velocity data collected at two locations within the study area to calibrate and validate the hydrodynamic model will provide sufficient confidence in the predictive capability of the model for the entire study area. The calibrated hydrodynamic model will provide transport information that will be used by the sediment transport model; however, re-calibration of the hydrodynamic model during development of the sediment transport is not required or expected.

The current velocity study is designed to capture two high-flow events. If two high-flow events do not occur during the one-month period, then the ADCP deployment and associated upstream sediment load study will be extended until the desired number of events has occurred. The mean flow rate in the San Jacinto River is 2,200 cubic feet per second (cfs), and a high-flow event with return periods of 2-, 10-, and 100-years correspond to flow rates of 38,400, 126,000, and 372,000 cfs, respectively (Anchor QEA 2010a). For the purposes of the current velocity study, a high-flow event will be considered to be an event with a peak

flow rate of 10,000 cfs or greater. The 10,000 cfs criterion was chosen because this flow rate is about five times greater than the average flow rate. Based on previous experience on other systems, the transition from low/moderate flow conditions typically occurs when the flow rate is about two to five times the average flow rate. This transition can be observed in typical sediment rating curves (i.e., TSS concentration vs. flow rate) which show the following behavior: 1) TSS concentration is not correlated to flow rate when the flow rate is less than one to two times the long-term average flow rate; and 2) TSS concentration increases with increasing flow rate when the flow rate is greater than one to two times the average discharge value.

Flow rate data for the San Jacinto River are available from two different sources. First, Coastal Water Authority data are available at the Lake Houston Dam beginning in 2007[1]. Flow rate at the dam is calculated based on a relationship between lake water level and the geometry of the dam. Second, for the period prior to 2007, daily average flow rates at the dam are estimated by summing up flow rate data from six USGS gauges located upstream of Lake Houston and prorating the summed flow rate by the ratio of the drainage area at the dam (2,828 square miles) to the sum of the drainage areas of the six upstream gauges (2,075 square miles), which produces a drainage area proration factor of 1.36. The six USGS gauges are: Luce Bayou above Lake Houston near Huffman, Texas (08071280); East Fork San Jacinto River near New Caney, Texas (08070200); Caney Creek near Splendora, Texas (08070500); West Fork San Jacinto River above Lake Houston near Porter, Texas (08068090); Cypress Creek near Westfield, Texas (08069000); and Spring Creek near Spring, Texas (08068500)[2].

1.2 Project Organization

Detailed project organization information has been provided in the Sediment SAP. Task-specific project organization information is provided below:

[1] Lake Houston Dam flow data obtained in March 2011 via personal email communication with Mike Kent (mkent@cwalps.org) from the Coastal Water Authority (http://www.coastalwaterauthority.org).
[2] Daily-average flow data can be obtained from the USGS National Water Information System (http://waterdata.usgs.gov/nwis/dv/?referred_module=sw). Access to each gauge station is by entering the Site Number (e.g., 08068500).

FSP Personnel Quality Assurance Responsibilities

Title	Responsibility	Name	Contact Information
Project Coordinator	Coordination of project information and related communications on behalf of IP and MIMC with USEPA; liaison between USEPA project managers and respondent project managers	David Keith	Anchor QEA, LLC 614 Magnolia Avenue Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com
Task Coordinator	Coordination of task project information and related communications with Project Coordinator	Kirk Ziegler	Anchor QEA, LLC 305 West Grand Ave Ste 300 Montvale, NJ 07645 (201) 930-9890 kziegler@anchorqea.com
Field Lead Anchor QEA	Field data collection and implementation of the Health and Safety Plan in the field	Daleel Nangju	Anchor QEA, LLC 10707 Corporate Drive Suite 230 Stafford, TX 77477 (281) 565-1133 dnangju@anchorqea.com
OSI Technical Lead	Responsible for coordinating field activities and post-processing of ADCP and CTD data	Ken Cadmus	Ocean Surveys, Inc. 129 Mill Rock Road E. Old Saybrook, CT 06475 (860) 388-4631 Ext. 126 kac@oceansurveys.com

1.3 Laboratories

The work performed under this FSP will not require laboratory services.

1.4 Document Organization

This FSP describes the field and data reduction methods that will be used to perform the current velocity study and prepare the survey dataset. The background, rationale, data quality objectives, and overall study design are described in detail in the Chemical Fate and Transport Addendum (Anchor QEA and Integral 2010b). Section 2 of this FSP describes the field and desktop procedures that will be followed by the technical team during the study. Section 3 summarizes field documentation procedures. Field data management and reporting procedures are discussed in Section 4.

The following documents are provided as attachments to the FSP:

- Standard Operating Procedures (SOPs). Attachment 1 provides the SOPs.
- Operation Guides and User Manuals. Attachment 2 provides information on the use of the ADCP and CTD.
- Survey Equipment Data Sheets. Attachment 3 provides information on the anticipated survey equipment.
- Field Forms. Attachment 4 contains examples of various forms that will be used during field work, including a corrective action record and a field change request form.
- USEPA Comments and Responses. Attachment 5 contains the USEPA Comments and Responses Matrix.

2 SURVEY PROCEDURES

The following sections describe the detailed procedures and methods that will be used during the current velocity study, including the schedule, survey procedures, record keeping, data analysis, and quality control (QC) procedures. All field activities will be conducted in accordance with the Health and Safety Plan (HASP; Anchor QEA 2009), which will be amended as needed to support the current velocity study tasks and Addendum 1 to the Overall HASP: Sediment HASP (Integral 2010).

2.1 Schedule

The start date for the current velocity study will be determined following USEPA approval of this FSP. However, for planning purposes, it is anticipated that the survey will be conducted during April 2011.

The ADCP will be deployed for a period of at least one month. It is anticipated that two high-flow events, with peak flows of 10,000 cfs or greater, will occur during this period. The deployment of the ADCP will be coincident with the proximal deployment of the Teledyne ISCO automated total suspended solids (TSS) sampler as part of the upstream sediment study. If the necessary high-flow events are not captured during the current velocity study, then the sampling period will be extended for another week at a time until the required data are obtained. The sampling period will not be extended by more than one month, for a total maximum sampling period of two months.

Contingency options (e.g., potentially extending deployment of the ADCP) will be assessed and discussed with USEPA at the end of the two-month deployment period if the necessary high-flow events do not occur. However, it is reasonably likely that the requisite high-flow events will occur during the planned monitoring period, based on a review of historical flow rate data collected at Lake Houston Dam.

2.2 Study Methods

As discussed previously, the current velocity study will be conducted near the vicinity of the Site, complimenting a previous current velocity study conducted as part of the TCRA Work Plan. The following sections describe the study equipment and sampling methods.

2.2.1 Study Vessel, Field Equipment, and Supplies

2.2.1.1 Study Vessel

The deployment of the ADCP into a water depth between 10 and 20 feet will be conducted by boat equipped with a mechanical winch system. A shallow draft skiff is planned to be used as the study vessel. The vessel will be equipped with navigation, positioning, and data recording systems. The vessel will have navigational lights, anchors, basic sonar, and all safety equipment (personal floatation devices, whistle or horn, and fire extinguisher) as required by the United States Coast Guard (USCG) and Texas Parks and Wildlife (TPWD 2006). The vessel operator will be thoroughly familiar with the area of the river to be navigated and will coordinate with the USCG Vessel Traffic System and Port of Houston security notification procedures, as applicable.

Weather, river gauge height, and tides will be monitored to maintain safety during on-river activities using the following websites:

- Weather conditions and forecasts: National Oceanic and Atmospheric Administration (NOAA) site for the Houston/Galveston area. (http://www.weather.gov/forecasts/wfo/sectors/hgx.php#tabs)
- Real-time stream elevation: U.S. Geological Survey (USGS) 08072050 San Jacinto River near Sheldon, 10 miles upstream from the Site. (http://waterdata.usgs.gov/nwis/uv/?site_no=08072050&agency_cd=USGS)
- Real-time data on wind direction, wind speed, and water elevation: USGS 08077637 Clear Lake Second Outflow Channel at Kemah, 22 miles south of the Site. (http://waterdata.usgs.gov/nwis/uv?site_no=08077637)
- Tides: NOAA site at Morgans Point, TX, Station Id: 8770613, located 10 miles southeast of the Site. (http://tidesandcurrents.noaa.gov/geo.shtml?location=8770613)
- Supplementary water surface elevation information may be obtained from staff gauges SG01 and SG02, located just offshore, east and west of the former impoundments. Top of gauges are 3.66 and 3.38 ft North American Vertical Datum of 1988 (NAVD88), respectively. Coordinates are 3216594.63 E, 13857474.61 N and 3217261.16 E, 13857107.46 N US State Plane 1983, Texas South Central 4204, respectively. Water surface elevation data from these staff gauges will be used to convert the water depth data from the CTD to a water surface elevation. Conversion

of the vertical datum from NAVD88 to project vertical elevation of mean sea level (MSL) will be made using the datum conversion table at the NOAA tide gauge station at Morgan's Point.

These data sources may be changed or augmented, as needed.

2.2.1.2 Field Equipment and Supplies

Field equipment and supplies include the following equipment (or equivalent), in addition to equipment and supplies used during boating activities:

- Differential Global Positioning System (DGPS) Positioning receiver, or equivalent (for example, Trimble DMS 232 using U.S. Coast Guard Navigation Beacon Corrections to provide sub-meter accuracy)
- Teledyne RD Instruments Workhorse Sentinel Self Contained 1200 kHz ADCP
- YSI 6920 CTD Sensor
- Bottom Mount System Gimbaled ADCP Platform
- Digicourse 2510 DigiRelease Acoustic Release
- Protective wear as described in the HASP (Anchor QEA 2009; Integral 2010)

The mount system is specifically important to secure the ADCP into an upward looking position, buttress the ADCP from the forces of river flow, and orient it correctly with respect to the north-south and east-west directions. Equipment data sheets are provided in Attachment 3.

2.2.2 Location Positioning

Horizontal and vertical positioning is critical for the proper deployment of the ADCP near the study area. All positioning calculations will be completed as described in SOP AP-06 (Navigation and Station Positioning) found in Attachment 1. A DGPS will be used to document the deployment locations. The standard horizontal datum projection to be used during field activities is NAD83 State Plane, Texas South Central, FIPS 4204, US feet. The positioning objective is to accurately determine and record the horizontal position of the deployed ADCP to within ±2 m.

The ADCP-CTD will be deployed approximately 700 feet offshore from the Upland Sand Separation Area as shown in Figure 2. The location of the 2011 ADCP deployment is shown as a black cross symbol on this figure. The location of the 2010 ADCP deployment is shown as a black circle and cross symbol on Figure 2. The ADCP system will be deployed on the sediment bed with an elevation of approximately -18 feet MSL. Bed elevation is based on sounding data from the NOAA National Ocean Service (NOS) and single-beam bathymetric surveys conducted in 2009 and 2010 in the vicinity of the Study Area.

Prior to deployment of the ADCP at the location shown on Figure 2, the sediment bed in the vicinity of that location will be scanned with an echo sounder to verify that bed slopes are less than 10% and that the water depth is consistent with bathymetric data. This process will ensure that the ADCP is properly positioned on the sediment bed. The ADCP needs to be placed on a relatively flat surface with bed slopes less than 10 percent (roughly equivalent to a 5 degree slope). The anticipated positioning coordinates of the ADCP in the channel are presented in Table 1. The coordinates are based on a horizontal datum projection of Geographic Coordinate System (GCS) North American Datum of 1983 (NAD83).

Table 1

Position Coordinates for ADCP Deployment

Longitude	Latitude
-95.06381 degrees West	29.80000 degrees North

2.2.3 Study Procedures

A self-contained, internally logging ADCP will be deployed in an upward looking configuration on a bottom mount equipped with a gimbal to accommodate slope at the deployment site. The operation of the ADCP will be in accordance with related manuals and guidance found in Attachment 2. Achieving the proper orientation and calibration of the ADCP and CTD will be based on the User Manuals. Before being deployed, the ADCP will be setup and calibrated according to related guidance found in Attachment 2 including:

- Checking that all accessories are included.
- Connecting the devices, including proper installation of the bottom mounts and external battery.

- Installing the software.
- Testing the devices.
- Proper orientation of the internal compass in the ADCP.
- Setting the vertical elevation in the CTD.

Placement of the ADCP will be conducted by boat. The ADCP and related equipment will be lowered from the boat using a mechanical winch. The instrument will be secured to a bottom mount in an upward looking position inside a gimbaled collar to keep the ADCP plumb. The collection of the ADCP and bottom mount is called the mooring. Schematic diagrams of the ADCP and the associated gimbaled collar can be found in Attachment 3. The specialized mooring will project 1.6 feet above the sediment bed. The mooring will be lowered to the sediment bed from the study vessel and once the mount has reached the bottom, the deployment line will be pulled off to the side and lowered to the bottom on a weight. For recovery, the field crew will hook the deployment line with a grapnel hook from the survey vessel and return the mount to the surface. In additional, an acoustic release and submerged float will be secured to the mooring as a second form of recovery.

A 1200 kHz ADCP will be used for this shallow-water application. The instrument is set to record an average burst of 180 water profile pings every six minutes with a vertical resolution of 0.25 m. This data collection regime results in a current velocity standard deviation of 0.96 cm/s. All times are referenced to Central Daylight Time (CDT), which is equivalent to Greenwich Mean Time (GMT) minus 5 hours.

The ADCP will record the depth-averaged (depth-integrated) current velocity, as well as the current velocity over a minimum of 28 bins. A bin represents the water column that has been divided into equal depth parts. For example, given an average water depth of 20 feet and assuming a mount height of 1.6 feet (0.5 m) and an ADCP blanking distance above the head of 0.78 feet (0.24 m), for a total system height of 2.38 feet, will result in about 17.6 feet (5.4 m) of water depth at the ADCP location. Due to bin interference with the surface, current velocity data will be collected to within approximately one bin width of the surface. Given a total of 28 bins, each bin will have a thickness of 0.82 feet (0.25 m) in the water column. The CTD will be attached adjacent to the ADCP and measure salinity at

approximately 1.6 feet (0.5 m) off the bottom. The accuracy of the current velocity, salinity, and water surface elevation measurements are 0.96 cm/s, 0.1 ppt, and 0.06 feet, respectively.

All instrumentation will be configured to record every six minutes to be consistent with the nationwide NOAA tide-monitoring program. The water depth sensor is a sub-surface pressure-sensing unit that measures hydrostatic pressure. As such, the pressure measurements made with the water depth sensor will be corrected for variations in barometric pressure that occur during the deployment period. Local barometric pressure readings will be obtained from the National Weather Service and used to calculate water depths.

2.3 Data Processing

Current velocity, water surface elevation, and salinity data will be reduced, organized and processed using available software. Teledyne RDI's Windows-based software includes:

- WinH-ADCP: Windows-based data acquisition and playback package for Horizontal ADCPs.
- WinADCP: Windows-based post-processing package for ADCP data.

The dataset will be reviewed and edited to result in an accurate temporal profile of the river at the given location. Quality control activities that will be conducted during post-processing of the data include removal of anomalous data, such as barge traffic occurring overhead during the study period, verification of salinity data, and removal of reflected velocity data above the water surface elevation.

2.4 Study-Derived Waste

All disposable materials used during the survey work, such as paper towels and gloves, will be placed in heavyweight garbage bags or other appropriate containers for eventual disposition in a normal refuse container. Contaminated materials are not anticipated to be generated.

3 FIELD DOCUMENTATION

3.1 Field Logs

All field change requests and updates will be recorded in the form shown in Attachment 4 (Field Change Request Form). This field log book will include information pertaining to personnel, date, time, station designation, study location, equipment calibration, and general observations. Any changes that occur during the study (e.g., personnel, responsibilities, deviations from the FSP) and the reasons for these changes will be documented. Each field lead is responsible for ensuring that their respective field log book and all field data forms are correct. Requirements for log book entries will include the following:

- Log books will be bound, with consecutively numbered pages.
- Removal of any pages, even if illegible, will be prohibited.
- Entries will be made legibly with black (or dark) waterproof ink.
- Unbiased, accurate language will be used.
- Entries will be made while activities are in progress or as soon afterward as possible (the date and time that the notation is made should be recorded, as well as the time of the observation itself).
- Each consecutive day's first entry will be made on a new, blank page.
- The date and time, based on a 24-hour clock (e.g., 0900 for 9:00 a.m., 2100 for 9:00 p.m.) will appear on each page.

In addition to the preceding requirements, the person recording the information must initial and date each page of the field log book. If more than one individual makes entries on the same page, each recorder must initial and date each entry. The bottom of the page must be signed and dated by the individual who made the last entry.

Log book corrections will be made by drawing a single line through the original entry, allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation.

The type of information that may be included in the field log book includes the following:

- Task start date and end date

- Name of person making entries and other field staff
- Any deviation from the FSP and reasons for deviation

All log books must be completed at the time that any observations are made. Copies of all log books and forms will be retained by the technical team.

3.2 Chain-of-Custody Procedures

During the study, the data will remain in the custody of OSI at all times. After the study, the data will be transferred to Anchor QEA via CD, including a report describing post-processing activities that were conducted.

4 FIELD DATA MANAGEMENT AND REPORTING PROCEDURES

During field operations, effective data management is critical to providing consistent, accurate, and defensible data and data products. Field data management will be performed as described in the Sediment SAP, and in Section 6.2 of Appendix A of the RI/FS Work Plan. Daily field records (a combination of field log books and field forms, if any) will make up the main documentation for field activities. Upon completion of the work, field notes, and data sheets will be scanned to create an electronic record. Field data will be manually entered into the project database. One hundred percent of the transferred data will be verified based on hard copy records. Electronic QA checks to identify anomalous values will also be conducted following entry.

Regarding electronic data obtained from instruments (i.e., the ADCP and CTD), recovery of data will be conducted in accordance with manufacturer's instructions (Attachment 2). Data recovery will be accomplished by total removal of the units from the deployment location and desktop data download and management. Electronic data backups will be made, and the dataset will be analyzed for potential erroneous points, using professional judgment, related site data and manufacturer's troubleshooting instructions, if warranted. Reviewed data will be reduced and uploaded in an appropriate format to the project database. Raw reviewed and original data will be maintained in the project files, both electronically and in hardcopy.

5 REFERENCES

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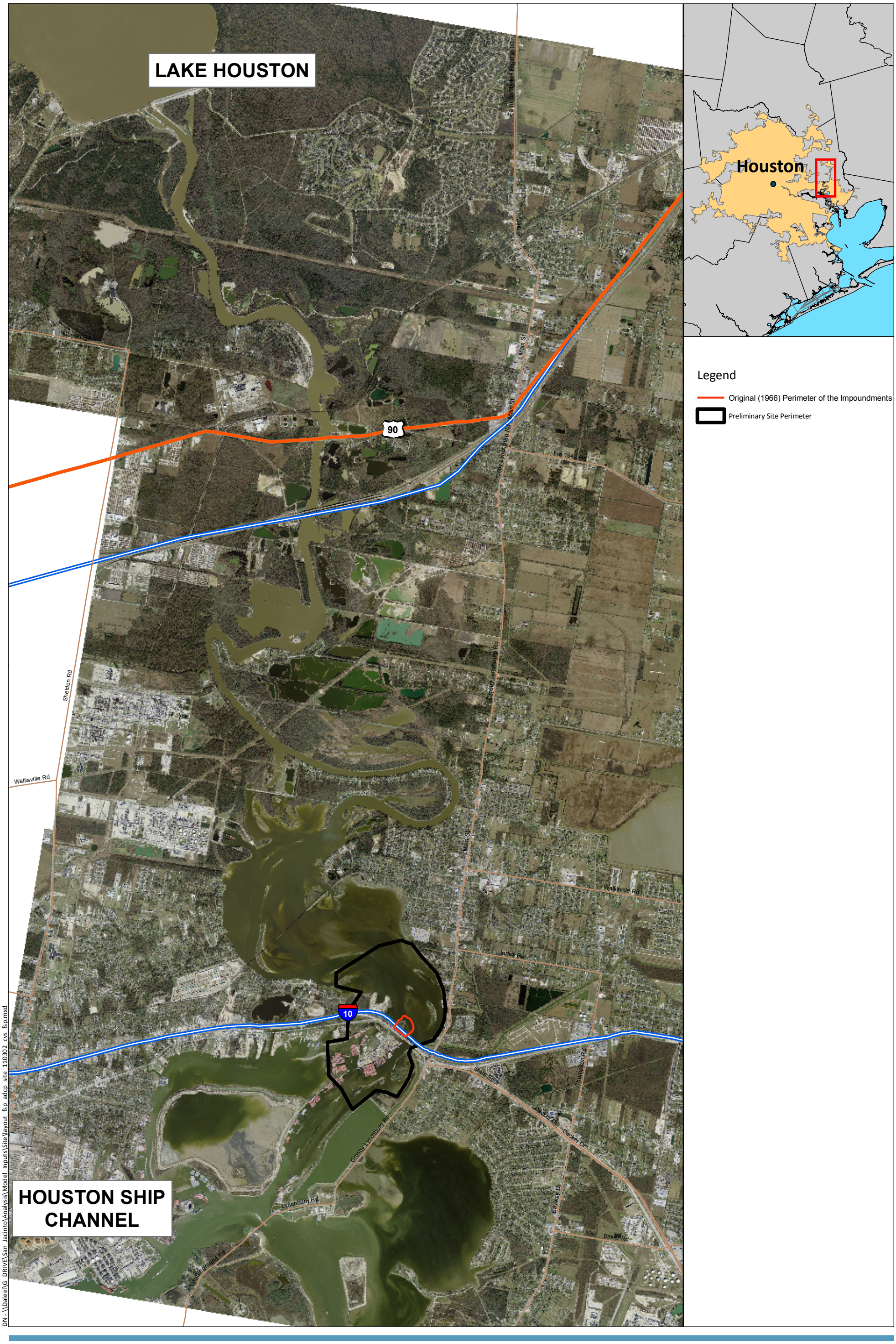
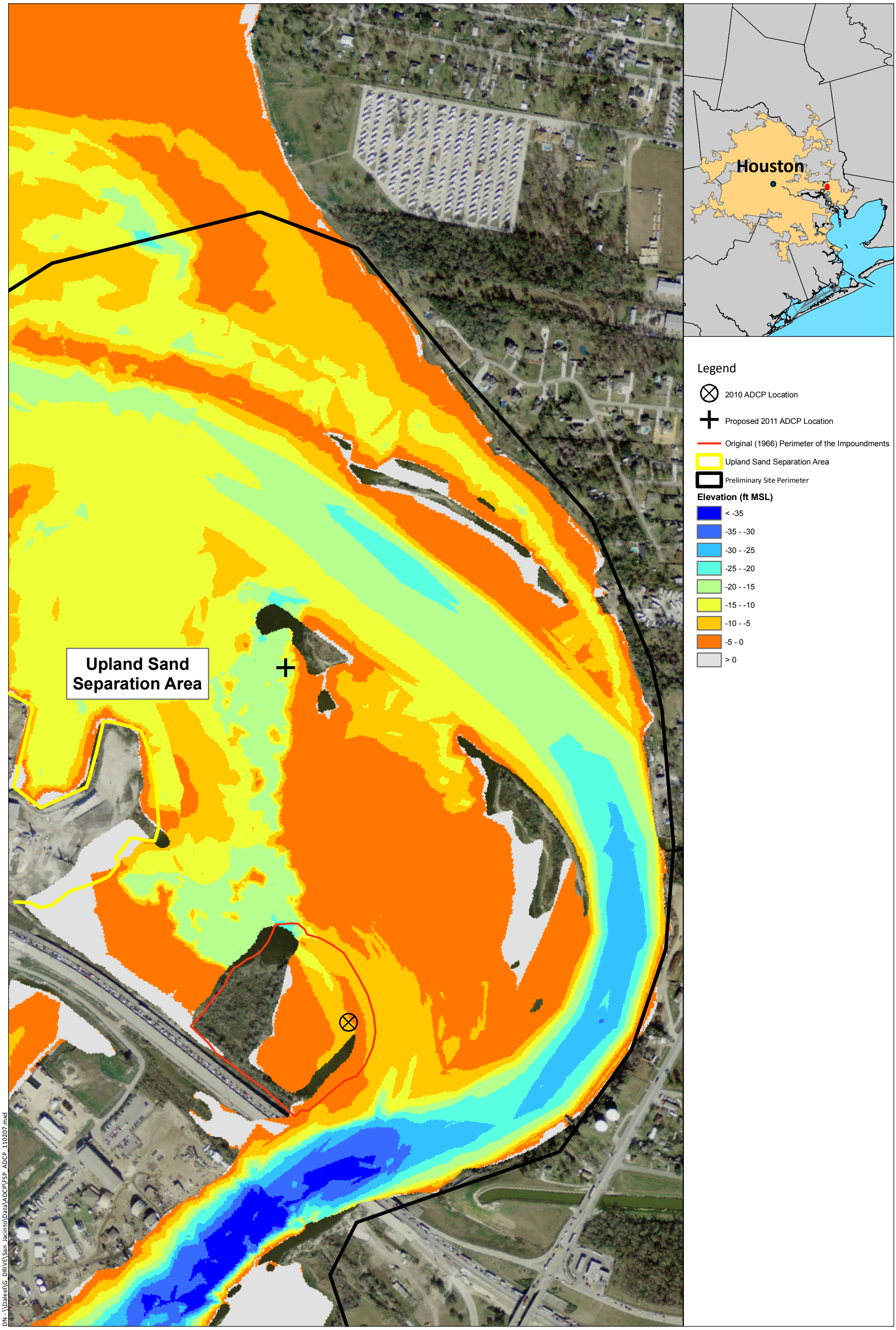
FIGURES



DN - \\Dal\eel\G_DRIVE\San_Jacinto\Analysis\Model_Inputs\Site\layout_fsp_adcp_site_110302_cvs_fsp.mxd

ANCHOR QEA

Figure 1
Site Map
Current Velocity Study FSP
SJRWP Superfund/ MIMC and IPC



ANCHOR QEA

Figure 2
Proposed Location of 2011 ADCP Deployment
Current Velocity Study FSP
SJRWP Superfund/ MIMC and IPC

ATTACHMENT 1
STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE (SOP) AP-06

NAVIGATION AND STATION POSITIONING

SCOPE AND APPLICATION

This SOP describes procedures for accurate station positioning required to ensure quality and consistency in collecting samples and in data interpretation and analysis. Station positioning must be both absolutely accurate in that it correctly defines a position by latitude and longitude, and relatively accurate in that the position must be repeatable, allowing field crew to reoccupy a station location in the future (e.g., for long-term monitoring programs).

This SOP describes the most commonly used station positioning method, differential global positioning system (DGPS). Integral uses a Trimble Pathfinder™ Pro XRS DGPS for station positioning for many field efforts. The Pro XRS offers the submeter accuracy often required for documenting sampling station locations and for re-locating previously sampled stations. A comprehensive discussion of the Trimble Pathfinder™ Pro XRS DGPS is provided in Attachments 1, 2, and 3 of this SOP.

SUMMARY OF METHOD

Global positioning system (GPS) navigation is used to position the sampler at the desired location. GPS is a satellite-based system that receives positioning data at 1-second intervals from multiple satellites at known positions in space. Standard GPS is calculated to an accuracy of about 10 m.

One can obtain a higher accuracy of approximately 2 m by applying differential corrections to the standard GPS positioning data using DGPS. These differential corrections are applied by sending GPS differential corrections to the GPS receiver via radio transmission. If the sampling location is near the coastal U.S, the U.S. Coast Guard generates differential corrections that are transmitted via radio link to the GPS receiver. If a Coast Guard station is out of range of the sampling area, then a receiver may be set up at a known (i.e., surveyed) reference point on land, or real-time satellite differential signals can be purchased from a private company (e.g., OmniSTAR).

With the Pro XRS, GPS data can be gathered to submeter accuracy using a choice of differential correction sources (i.e., free beacon differential signals such as Coast Guard beacons or OmniSTAR) without establishing a reference station. Data must be corrected to gain submeter accuracy. Free beacon or base station signals allow differential corrections to be

performed after data collection by using a nearby beacon or base station logging data files. (Note: The station must be within 300 miles of the data collection location.) For satellite-based signals, a built-in virtual base station allows for real-time data correction, eliminating the need for post-processing data in some cases. However, postprocessing data corrections can obtain accuracies in the range of 30–50 cm. These accuracies are for the horizontal (northing and easting) component only. The vertical component (elevation) accuracy ranges from submeter to 3 times larger than the horizontal accuracy.

The GPS receiver displays and transmits differentially corrected positioning data to the computer using an integrated navigation software package (e.g., HYPACK, Terrasync). The computer data are typically displayed and recorded in World Geodetic System of 1984 (WGS-1984) geographic coordinates (latitude/longitude). However, the integrated navigation system can display and record information in other datums (e.g., UTM, NAD83). The integrated navigation system, acting as a data manager, displays the sampler's position relative to a target station location in plan view on a video screen. The resulting pictorial screen presentation, as well as numeric navigation data (e.g., range and bearing to the target sampling location) assists the vessel operator (when sampling on-water) in approaching and maintaining the station position while sampling.

SUPPLIES AND EQUIPMENT

- Cable
- GPS antenna
- Telemetry antenna (for differential corrections)
- GPS receiver
- Differential corrections receiver
- Computer and monitor
- Navigation software (e.g., Terrasync)
- Logbook or log sheets.

PROCEDURES

Obtain latitude and longitude coordinates at the locations where samples are collected. An average positioning objective is to accurately determine and record the positions of all sampling locations to within 2 m. Positioning accuracies on the order of 1–3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS provides the operator with a listing of the time intervals during the

day when accuracies are decreased. Avoiding these times allows for better positioning accuracy.

On-Land Sampling Event

A backpack DGPS unit may be used to direct the sampling team to the proposed sampling location. To expedite field activities, enter the target station coordinates into the navigation system database prior to beginning sampling. Place the DGPS antenna as close as possible to where the sampling will occur. Once the sample(s) have been collected at the appropriate location, record the horizontal coordinates of the station in the field logbook.

On-Water Sampling Event

Mount the GPS antenna vertically at the outboard end of the vessel's boom, with the GPS antenna cable extended along the boom into the cabin. Mount the telemetry antenna for receiving differential corrections on a convenient fixture outside the cabin. Locate the GPS receiver, the differential corrections receiver, and the computer in the cabin. Orient the video screen for the computer to allow the vessel operator to observe on-screen positioning data from the helm.

Alternatively, use a backpack DGPS unit to position the sampling vessel (e.g., barge) over a proposed sampling location. Place the DGPS beacon as close as possible to where the drilling will occur (i.e., moon pool). Using the DGPS unit, direct the sampling vessel operator to the sample station location.

Once the sampling vessel is anchored at the appropriate location, record the horizontal coordinates of the station in the field logbook. To expedite field activities, enter the target station coordinates in the navigation system database prior to beginning sampling.

Positioning System Verification

GPS requires no calibration, as all signal propagation is controlled by the U.S. government (the Department of Defense for satellite signals and the U.S. Coast Guard for differential corrections). Verifying the accuracy of the GPS requires coordinates to be known for one (or more) horizontal control point within the study area. The GPS position reading at any given station can then be compared to the known control point. Verify the GPS accuracy at the beginning and end of each sampling day.

Station Positioning Activities

Use a consistent routine for each day's positioning activities. After confirming successful reception of differential signals, turn on the computer on, and the boot the software. Verify the accuracy of the system at a horizontal control point, as described in the previous section.

The sampling team proceeds to a target station location selected by the team leader. That station location is then selected from a number of preselected station locations that have been entered into the integrated navigation system database. Once the station has been selected, the positioning data are displayed on the computer screen or hand-held unit to assist in proceeding to the station and in maintaining the station position during sampling. A confirmed position is recorded electronically each time a sample collection is attempted. (This means that during sediment grab sampling and coring, the locations of both accepted and rejected grabs or cores are recorded.) Upon recovery of the sampling device, read the station position northing (y) and easting (x) coordinates from the archived computer file and record them in the field logbook or on log sheets as a backup to the computer record. Also record time and water depth, if applicable. Ancillary information recorded in the field logbook may include personnel operating the GPS, tidal phase, type of sampling activity, and time when coordinates were collected.

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ATTACHMENT 1
PRO XRS DESCRIPTION

The Pro XRS combines a high-performance GPS receiver and antenna, beacon differential receiver, and satellite differential receiver in one compact unit. It also includes Trimble's advanced Everest™ technology, which allows users to collect accurate position data near walls, water, vehicles, or other surfaces that reflect satellite signals. Reflected signals, also called multipath signals, make it difficult for GPS receivers to accurately determine position. Everest™ uses a patented technique to remove multipath signals before measurements are used to calculate position.

Equipment Required

The GPS Pathfinder™ Pro XRS consists of the following:

- GPS receiver in backpack casing (with system batteries and cables)
- Hand-held data logger (TSC1) and cable, *or* laptop computer with Terrasync software installed and cable. (Note: Terrasync procedures are described under separate cover.)
- Pro XRS antenna, range poles, and cable
- Compass and tape measure
- Spare 12-volt camcorder and 9-volt batteries (minimum of two each) (use only Kodak, Duracell, or Energizer 9-volt batteries)
- Battery charger and power cord.

Pro XRS Setup

Follow these procedures for the proper setup of the Pro XRS:

1. Ensure that connections between batteries, receiver, and data logger are correct and secure. The coaxial antenna cable connects from the GPS receiver port "ANT" to the base of the antenna. The TSC1 cable (a "pig-tail"-type cable) connects from the bottom or top of the TSC1 to the receiver port "B," where a 9-pin serial port dongle is attached. The dual Y-clip cables should be connected from the receiver to the batteries. Alternatively, if AC power is available (e.g., aboard a vessel), then the power cable for the battery charger can be attached directly to the receiver on some models.
2. Screw the three long antenna poles together (the shorter pole may be added if necessary for taller users). Screw on the antenna and connect its cable.
3. Put backpack and/or shoulder strap on. The pouch for the data logger should be in place around the waist strap or in the backpack.

4. Screw antenna to the attachments on the top of the backpack. Wind cord around pole, and ensure the antenna is secure. Please be aware of overhead hazards, especially if working near low-hanging power lines. Severe injury or death can result.

Basic Operation of the Pro XRS

Recording a Feature

Before beginning field use, ensure that all GPS configurations and settings are set correctly for the particular use of the Pro XRS and that an appropriate data dictionary is loaded onto the TSC1 (see Attachments 2 and 3 for typical settings). These steps outline the basic use of the GPS to document a sample position or any other defined "feature." Note that the TSC1 has both hard and soft keys that allow for its operation. The hard keys comprise all of the keys (e.g., letters and numbers) on its surface. The soft keys are the F1 through F5 hard keys. The function of these changes depending upon the context. These keys will be referred to with brackets around them (<soft-key>).

1. Turn data logger on outside in an open area. Wait for antenna to receive satellite signals. The display will read Recording Almanac, Too Few SVs, and PDOP Too High. Continue to wait until enough satellites (four) are acquired and the PDOP is below 5.0.
2. Ensure that the real-time settings are correct according to the parameters listed in Attachment 2.
3. Select **Data Collection**, and create a new rover file or open an existing file. This file should be named according to the format specified by the project GIS analyst. Note: If opening an existing file, press **<NEW>** to access the *Antenna Options* menu and *Start Feature* menu.
4. Enter the height of the antenna from the ground to the *Measurement Method* reference point shown in the *Antenna Options* menu and then press **ENTER** to bring up the *Start Feature* menu.
5. Pick the appropriate data dictionary to use with the rover file. Only one dictionary can be used with a rover file. Consult with the project GIS analyst to formulate the most appropriate data dictionary for the type of sampling you wish to perform. The data dictionary titled *Generic* contains only a comment field and is appropriate for simple navigation tasks. If using a data dictionary, make sure to become familiar with its attributes before recording information in the field.

6. Move to the location of the first feature for which you want to record the GPS position. Select the appropriate feature and press **ENTER** to begin logging. Log data points in accordance with the feature type. Point features should have at least 10 points collected at a stationary location. Line features should be collected while moving. If movement is stopped, press the **<PAUSE>** key. When movement starts again, press the **<RESUME>** key. Area features should be collected with enough points to define the outline of the area (e.g., a square building would have four single points, collected on each corner, and the **<PAUSE>** key would be used between each of the points).
7. Depending on the setup of the data dictionary, each feature may have one or more feature attributes. An attribute is used to record additional data associated with the feature. For example, the attributes assigned to a sediment sampling station could be the sample number, station ID, sampling gear, sediment color, odor, etc.
8. Use the **<PAUSE>** key while recording feature attributes to avoid too many data points being collected at one point feature. (Body movements while logging attributes for an extended time can decrease the accuracy of collection.) The **<PAUSE>** key must be used when recording attributes of a line or area feature because only one data point should be collected in a single location.
9. Once all attributes are entered and the feature data points are logged, press **ENTER** to complete and save the feature and move on to a new feature. Pressing **ESC** instead of **ENTER** will allow the user to abandon the logged feature without saving.
10. When all features in a given area have been recorded, from the *Data Collection* menu, press **ESC** to exit data capture and then press **<YES>** to close the file. Features are appended and saved to the file after each collection, so there is no need to "save" the file. When the Pro XRS is not in use, it should be turned off. If you need to come back to the same rover file later in the day, the rover file may be reopened at that time. Rover files may not be edited after 7 days from the first feature was created. Please consult the project GIS analyst for the best way to handle multi-week sampling projects.
11. At the end of each day, download the rover file to a PC using Pathfinder Office software.

Feature Collection Options

Offsets—The Pro XRS can collect a point or line feature while standing at a set distance away from the feature. This option may be necessary because of obstructions such as tree cover, buildings, or car traffic. For a point feature, measure the distance between the object you want recorded and the Pro XRS antenna. Use the compass to determine the bearing (e.g., west is 270°). The bearing is the direction the point should be moved for it to be located in the correct place (e.g., if you are due north of the feature, the bearing is south, or 180°; i.e., the position you want recorded is south of where you are standing). Estimate the inclination from the

feature to the GPS antenna (if altitude determination is critical, a clinometer should be used). The inclination is the degree angle up from the feature to the antenna (e.g., if the feature is 5° below the antenna position, enter −5°). During data capture, from within the feature, press the **<OFFSET>** button, and enter the distance, bearing, and inclination. Press **OK** to complete the feature. Note: This procedure describes an offset of a single feature. A constant offset may be applied to all features collected as well.

Nesting—While recording a line feature or an area feature, a point feature may be collected to avoid backtracking. While recording the line or area feature, press **<PAUSE>** and then **<NEST>**. The Pro XRS will prompt for collection of a new feature. Move to the feature, and collect data as for any other point feature. When the feature is complete, press **OK**. The Pro XRS is ready to resume collecting data as part of the line/area feature: press **<RESUME>**. (Remember to continue moving before pressing resume to avoid having multiple positions recorded in the same place in the line or area feature.)

Segmenting—While moving along a line feature, changing the attributes of that line may be necessary (e.g., because of a change in surface type from paved to dirt road). This change may be done without having to begin a new feature by pressing **<PAUSE>** and then ****. Change the appropriate attributes and then press **<RESUME>** to continue recording.

Repeat—This function allows the collection of a new feature with the same feature attributes as the previous feature. If features are not exactly the same, it also allows editing of the attributes.

Quickmark—Allows collection of point features while moving (e.g., from a car or a boat) by estimating the exact location. The use of this feature will not result in positionally accurate locations and is not recommended for most sampling operations.

Reviewing and Editing Features

It is possible to review or edit features collected in the field while still in the data capture mode. For example, it may be necessary to document the GPS location in the field logbook or to edit one of the feature's attributes. Without exiting data capture, press **<REVIEW>**. (If data capture is already complete, just press **<REVIEW>** and then select the appropriate rover file.) This step will display a list of data points including each feature collected. Scroll to the appropriate feature, and follow the steps below depending on the required action:

- To view the GPS location (e.g., lat/lon), press **<POS>.**
- To edit the attributes, press **ENTER**. Make any necessary edits to the attributes by scrolling through.
- To change or add an offset, press **<POS>** and then **<OFFSET>**. Make any necessary changes.
- To delete a feature collected in error, press **<DEL>**.

Navigating to an Existing Location

Waypoints

To use the Pro XRS to navigate to a previously established position, this position must be loaded into the data logger as a waypoint, present as a feature position in the data files, or generated in the field using the GPS unit. Waypoints may be entered into the TSC1 by:

- Entering coordinates manually
- Choosing previously recorded locations and importing them into the TSC1 by using Pathfinder Office
- Defining a location stored in a rover file saved to the TSC1 as a waypoint (see *Reviewing/Editing Features*, above)
- Creating a way point from the current position being shown by the operating GPS unit in the field.

Navigating

Usually you will use the *Navigation* module (accessed by pressing **MENU** followed by **Navigation**) to guide yourself to a target (waypoint or feature). You can also use the *Map* module (accessed by pressing **MENU** followed by **Map**) to:

1. Orient yourself in the area where you are working.
2. Get a general indication of the location of a feature or waypoint that you want to find.
3. Find or select features or waypoints to which you wish to navigate toward.
4. Plot a course from one place to another.
    a. While in the Map screen, the GPS cursor x shows the current position reported by the receiver and is always shown on the Map screen (Note: it may not always be within the visible part of the screen when panning or scrolling). The **<OPTIONS>** key can be used to hide or display the GPS trail (line of dots showing up to 60 previous positions), the heading showing the direction of travel, and other options on the map display.
    b. Select a feature by pressing **MENU**, Data Collection to reach the *Start Feature* screen, and then **<REVIEW>** to access all features contained in the data file. Highlight and select the desired feature by pressing the **<Target>** key, which adds a crossed flag to the feature. Reaccess the *Map* screen by selecting **MENU**, then **Map**, which will now show the highlighted feature with a crossed flag symbol on the Map screen. You can then start moving toward the feature, and the current position (shown by the x) will move closer to the target position as the user approaches.

c. There are two graphical modes of navigation with the Pro XRS in the TSC1 *Navigation* module. On both modes, text information appears on the right of the screen in the *Info* panels, which can be configured by the user. The graphical modes available are the *Directional Dial* screen or the *Road* screen, which can be toggled between using the **<Mode>** key.

d. To navigate, select a target and then a start position. Each of these positions can be features from an open data file or a waypoint. Access a list of available features or waypoints by pressing **<TARGET>** or **<START>**. Once the item has been chosen as a target, it will show the crossed flags symbol in the list. Once a target has been selected, *Distance to Go* appears at the bottom of the *Navigation* screen, which indicates the distance from the current GPS position to the target. Select a start position (not required but useful for calculating crosstrack error and other navigation information) by pressing **<START>**. A waypoint of the current GPS position can be created for use as the Start point by selecting **<CREATE>**. Once the Start position is selected, a flag symbol will appear next to the item in the list.

e. In the *Directional Dial* mode, an arrow will appear that will always point at the target. This is the bearing to go. (Note: You need to be moving for this to be accurate, as it will lock if you are moving too slowly or have stopped.) The triangle at the top represents the direction that you are going or heading. This triangle never moves, but by changing directions, you can line up the arrow with the triangle. When the two are aligned, you are heading in the direction of the target. When you are close to the target, a bull's-eye (two concentric circles) will appear at the edge of the screen. This is warning you that the unit will be switching to the close up screen. A proximity alarm will sound and the directional arrow will be replaced by the bull's-eye on the close up screen. Your current position will be shown by an x and the target by the bull's-eye. Move so that the x is in the same location as the bull's-eye.

f. In the *Road* mode, navigate by walking down a road. Your position is shown by a stick figure and is always positioned in the center of the screen. The target (crossed flags) shows the point to which you are navigating toward. Your heading is shown by the top center of the screen and the bearing to go is shown by the direction of the road, which will rotate as you change your heading. Change your heading until the road is pointing at the top of the screen (*Target* is also at the top of the screen) and the edges are parallel to the sides of the screen. As you move toward the target the screen zooms in, so the road appears to get wider.

Downloading Rover Files

Upon returning to the office, download all rover files from the TSC1 to a PC for post-processing. You will need the Trimble Pathfinder software installed on your computer. If you

are not using a field laptop that already has the program installed, contact your project GIS analyst for instructions on how to install the software.

Connect the TSC1 to your computer using the appropriate cables. In addition to the "pigtail" cable, you will also need a null modem (a 9-pin female-to-female cable) to plug into a PC serial port. Once connected, power up the TSC1 unit and navigate to *MENU>File Manager>File Transfer*. Then, open the Pathfinder software and navigate to the *Utilities>Data Transfer…* window from the menu bar. Select **GIS Datalogger** on COM1 (for most computer systems), and press the green **Connect** button. Download files from the TSC1 by selecting the **Receive** tab and choosing the data file type from the *Add* pulldown menu (Figure 1).

After downloading, remove all rover files and waypoints from the TSC1 to conserve memory. Rover files may be deleted from the *File Manager* menu as follows:

1. Select **MENU>File Manager>Delete File(s)**
2. Select the rover file to be deleted, and press **<ENTER>**
3. Confirm the deletion of this file by pressing **<YES>**.

Delete data dictionaries in the same manner by selecting **Data Dictionaries** from the *File Manager* menu. Delete waypoints by selecting **Utilities** from the *Main* menu and then by selecting **Waypoints,** followed by **<DEL>**.

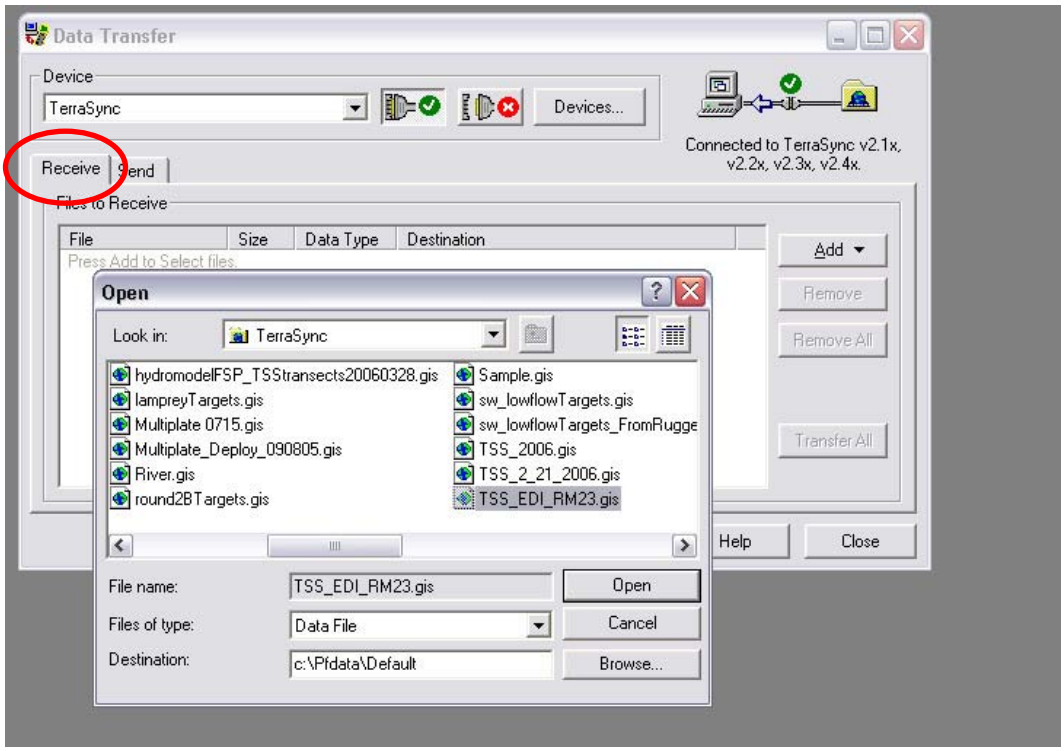

Figure 1. Transferring File from Terrasync

ATTACHMENT 2
TSC1 SETTINGS

The following are lists of menus that can be accessed through the TSC1 keypad. Please ensure that settings are correct before proceeding. Do not make changes to the settings unless necessary. Each menu will list all available subheadings, the correct setting, and the available **<soft-keys>** to access additional menus. Comments are included only where necessary.

GPS Rover Options

To access this menu, select **Configuration** from the main menu and then select **GPS Rover Options**. The table below lists logging options and settings.

Logging Options	Setting	Comment
Logging intervals		
Point feature	1s	
Line/area feature	2s–5s	depending upon speed of movement
Not in feature	None	
Velocity	None	
Confirm end feature	No	
Minimum pos	10	
Carrier Mode	Off	
Carrier phase min. time	10 minutes	
Dynamics code	Land	May be changed to sea or air, as appropriate
Audible click	Yes	
Log DOP data	Yes	
Log PPRT data	Yes	
Log QA/QC data	Yes	
Allow GPS update	Warn First	
Warning Distance	Any	
Position Mode Manual	3D	
Elevation Mask	15°	Should not go below 13° (accuracy decreases)
SNR Mask	6.0	Can raise to 7 if multi-path filtering is poor
PDOP Mask	5.0	Can be raised up to 8; reduces accuracy
PDOP Switch	6.0	

Real-Time Input Options

Access this menu from the GPS Rover *Options* menu by selecting **Real-Time Input**. The table below shows options and settings for real-time input.

Options	Setting	Comment
Preferred Correction Source		
	Choice 1	Integrated Beacon
	Choice 2	Integrated WAAS
	Choice 3	Use uncorrected GPS
Correction Age Limit	20s	

Antenna Options

Access this menu from the GPS rover *Options* menu by selecting **Antenna Options**. The table below shows antenna options and settings.

Option	Setting	Comment
Height	6 ft	Enter correct user antenna height using measurement method indicated below
Measure	Uncorrected	
Type	Integrated GPS/Beacon/Satellite	
Confirm	Per file	Can be changed to “Per feature” if antenna height varies and elevation is critical
Part Number	33580-50	Auto selected based on TYPE selected
Measurement	Bottom of Antenna	
Method	Mount	

ATTACHMENT 3
ADDITIONAL SETTINGS FOR THE TSC1

Additional TSC1 settings can be found in the *Configuration* menu. Items of particular importance are indicated in italics.

Configuration

This menu can be accessed by selecting **Configuration** from the main menu. The table below lists options and descriptions for the *Configuration* menu.

Options	Description
GPS base station options	For using a land base station or beacon for real time corrections
NMEA/TSIP output	Consult manual
Coordinate system	Changes coordinate system among latitude/longitude, UTM, and other coordinate systems. System can be converted, if necessary, after data capture by using Pathfinder Office software.
Map Display options	Change layers, scale, background files and items shown on the TSC1 screen during data collection
Navigation options	Changes Navigation parameters
Units and display	Changes various units, for example: length (e.g., feet, meters), altitude reference (e.g., MSL), *North reference* (i.e., true or magnetic). Units can be converted, if necessary, after data capture by using Pathfinder Office software.
Time and date	Changes to *local time*, 24-hour clock, date format, and other options
Quickmarks	Set-up parameters for use with Quickmarks.
Constant offset	Set-up parameters for use with a constant offset.
External sensors	Connections with external sensors.
Hardware (TSC1)	TSC1 settings such as beep volume, contrast, *internal and external battery status*, software version, free space.

Contrast and Backlighting

The TSC1 display can be viewed in various light settings. Press **FUNC,** then **L** to turn on the display backlight for viewing in dim lighting. Adjust the contrast by pressing **FUNC**, then **E** or **F**.

ATTACHMENT 4
PRE-SAMPLING ACTIVITIES BEFORE USE OF THE PRO XRS

Determination of Optimal Satellite-Use Time

Positioning accuracies on the order of ±1 to 3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS unit provides the operator with a listing of the time intervals during the day when accuracies are decreased. Avoiding these time intervals permits the operator to maintain better positioning accuracy.

ATTACHMENT 5
MANAGING GPS DATA FROM TERRASYNC—A TUTORIAL

Currently, positional data collected in the field is most often done with a Trimble GPS unit (usually rented) interfaced with a laptop via Trimble's Terrasync software. The Terrasync software sometimes exhibits quirks that interfere with the smooth operation of data collection in otherwise stressful field conditions. This tutorial is meant to supplement the Terrasync software documentation and serve as a guide to field personnel to help them retrieve and collect geographic data as efficiently as possible with existing software.

Scope

This document is intended to be a reference for procedures involving the following:

- Fixing files that are more than 7 days old so that they can be updated
- Adding features in GPS Pathfinder software (companion to Terrasync) and then importing them as base files in Terrasync..

This document is not intended to be a comprehensive manual for using Terrasync or Pathfinder software. It is assumed that the reader has received at least some training on how to use the basic features of Terrasync and is competent at using MS Windows.

The Basics

GPS data collection currently relies on two pieces of complementary software:

- Terrasync—the interface for GPS navigation and data collection.
- Pathfinder Office—a multiuse piece of software that acts as a conduit between GIS data files (shape files) and Terrasync GPS files. Pathfinder can also be used as a simple map editor.

Installing the Correct Versions of Terrasync and Pathfinder

Important Note: This tutorial uses Pathfinder Office v. 3.00 and Terrasync v. 2.50. It is very important to use the proper versions of this software to avoid compatibility issues. These software versions should be included in the same folder as this tutorial, or can be obtained from GIS staff.

http://www.trimble.com/terrasync_ts.asp?Nav=Collection-4576

Key code for TerraSync
499043-00110-05273-EDD049BC

Pathfinder v.3.00
001533-00300-04152-0ee4d11f

Initial Setup of Terrasync/Pathfinder

Certain settings and configuration setups are needed before Pathfinder can talk to Terrasync. Whether you are installing this software for the first time or have an existing installation, check to make sure that these settings are in place.

1. Open Pathfinder Office and go to the *Utilities>Data Transfer...* menu. A dialog box should appear. This is the interface for communicating with Terrasync.
2. Click the **Devices** button, and then **New…** (Figure 1).
3. Click on **GIS Folder**.
4. Browse to the Terrasync data folder on your computer, which in most cases will be *C:\My Documents\TerraSync*.
5. In the next box, *Type* will be **Terrasync**, and *Version* will be **v. 2.1x, v.2.2x, v.2.3x,** and **v2.4x**.
6. At the prompt for a name that will display in the device list, enter **Terrasync**.
7. Go back to the Data Transfer dialog box, select **Terrasync** from the dropdown menu, press the **Connect** icon, and look for a green check mark indicating success.

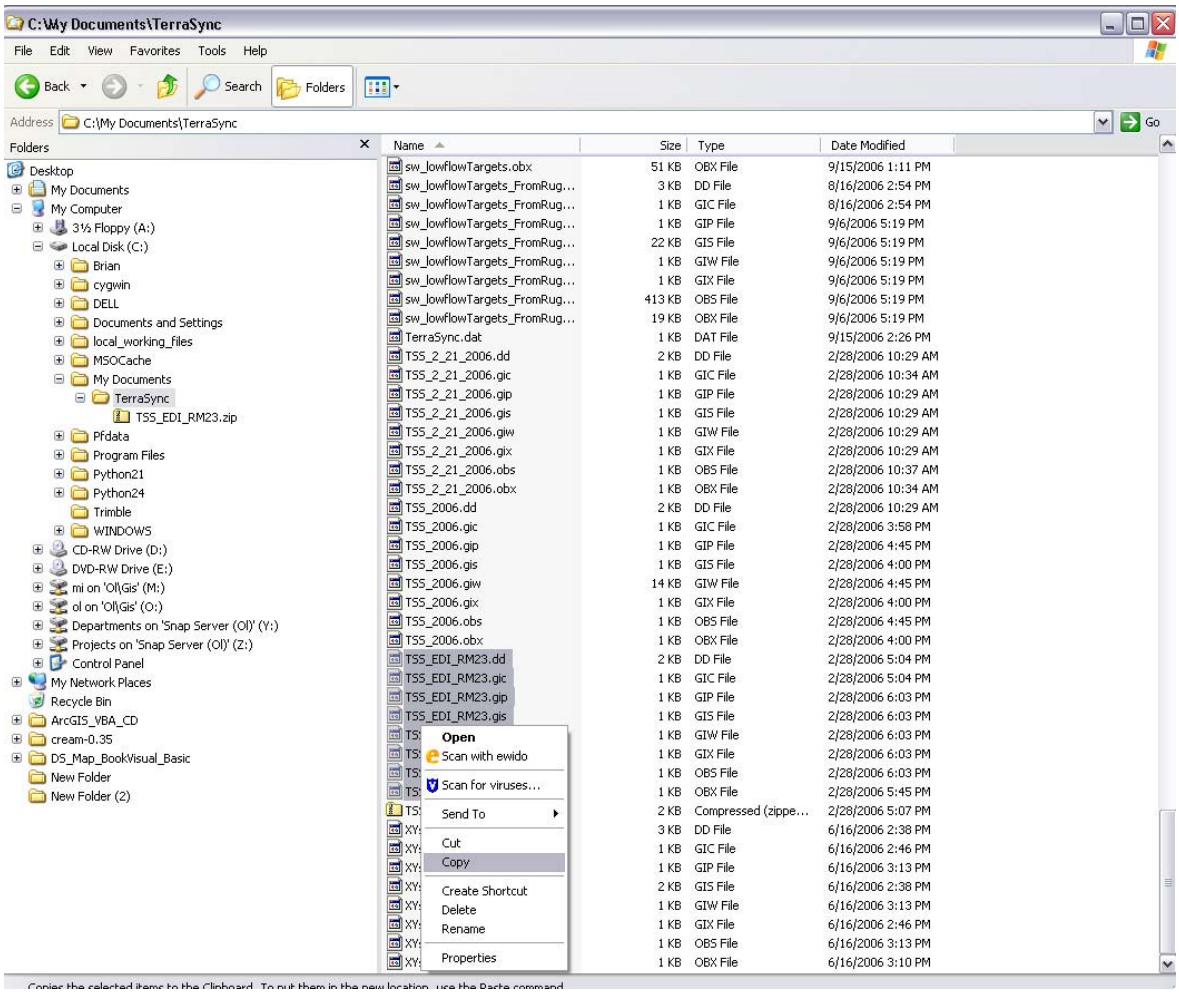

Figure 2. Selecting Files To Copy to a Different Directory

If this procedure does not work for you, you may have the wrong version of Pathfinder. For some unknown reason, with each version upgrade of Pathfinder, connectivity to older versions of Terrasync is lost. You can check what version of Pathfinder you have installed by going to the *Help>About GPS Pathfinder Office...* menu. To find out what version of Terrasync you have, go to *C:\Program Files\TerraSync*, right-click on **Terrasync.exe**, and choose the **Version** tab.

Handling Expired Files in Terrasync

One of the most common problems that field personnel will have to deal with is the 1-week expiration date when trying to collect data with Terrasync. This is a built-in function of Terrasync, and there is no simple way to work around it. The following instructions will guide you through the process to make the files usable. See Figure 3.

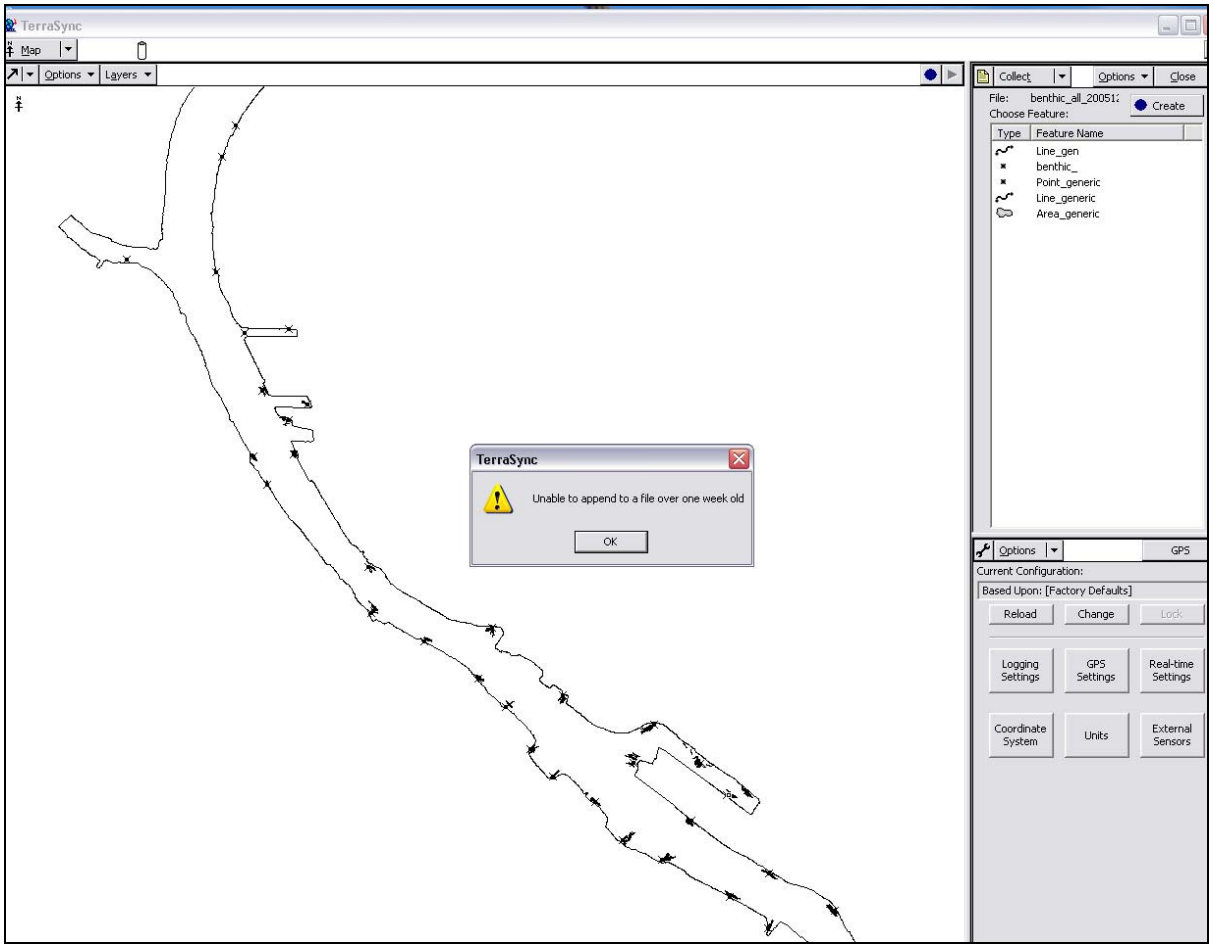

Figure 3. Notice That Terrasync File Older Than 1 Week Will Not Allow User To Collect Features (time begins to elapse when first feature is collected in the field, not when file is created)

Two options are available, depending on your needs. If you do not need to see the previously logged locations and need only to see the targets, use the original files provided by GIS staff (Option 1). If you need to see previously occupied locations in order to make decisions about where to go next, then transfer the file to Pathfinder and back again (Option 2).

Option 1: Move and replace logged files with original targets.

At the beginning of the field effort, you should receive a set of files with the target locations, most likely in a zip archive (.zip file extension). There will be six to eight files with the same name but with different extensions (Figure 4). These files will have to go into the *C:\My Documents\TerraSync* folder in order to be available to Terrasync.

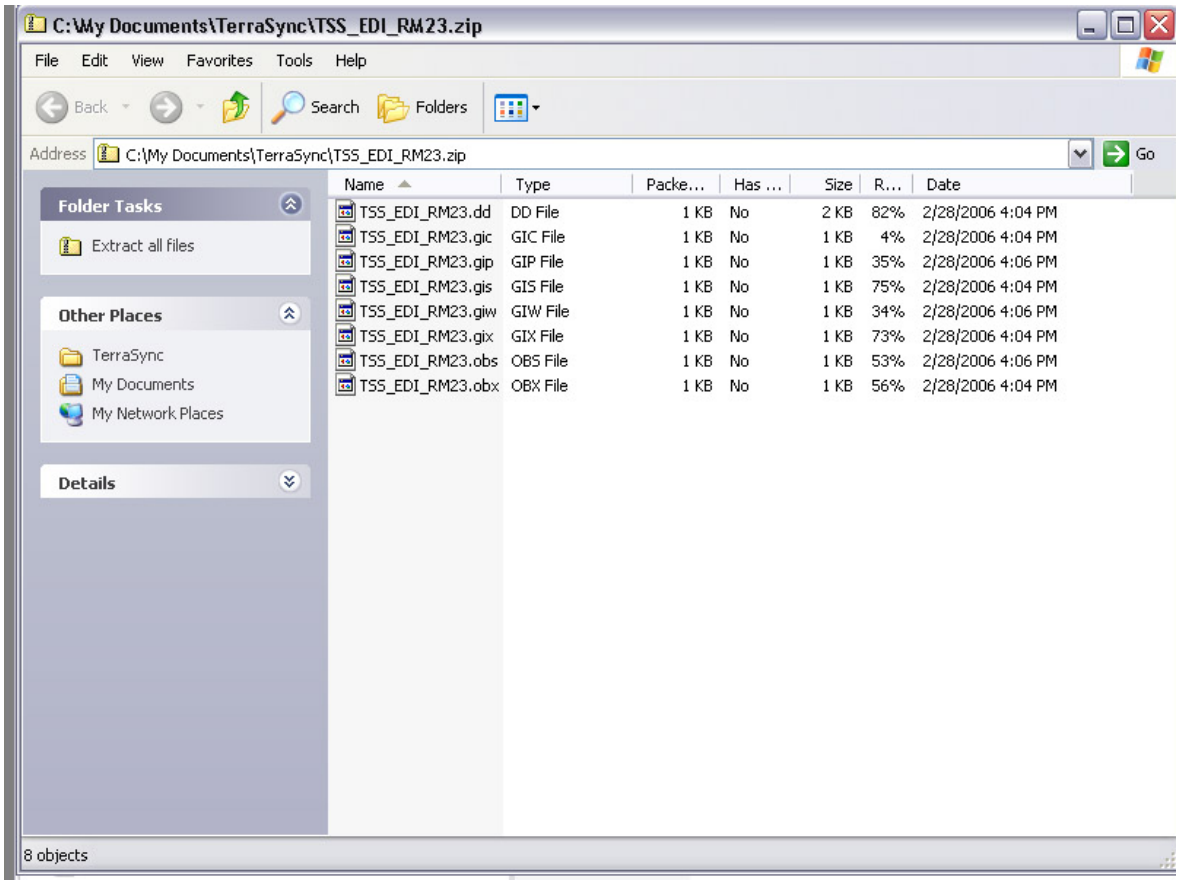

Figure 4. Example of File Set To Be Unzipped into the Terrasync Folder

After you unzip these files to Terrasync, keep this zip archive around in an easy-to-find place, such as your computer desktop, because the 1-week clock does not start until you begin collecting your first point in the field. You can use this unadulterated file again, as long as you make a copy of the work you did the previous week. The detailed steps are as follows:

1. Make sure you have the original files with the target locations available in a handy place. This will probably be the original zip archive. Also, be sure to close Terrasync while performing this process.
2. Navigate to C:\My Documents\TerraSync\ in Windows Explorer. Locate the files that you have been using the previous week. Note: It is crucial to get all of the small files associated with the data set. While it is useful to sort the files by date modified, you can miss some of the small files—it is highly recommended that you sort the files alphabetically.

3. Copy all of these files to a different directory, preferably one that is named appropriately to reflect the data and time period that you were collecting. For example: C:\Documents and Settings\bpointer\Desktop\lampreyTargets_20060925. These files contain the data you have collected the previous week and should be backed up and/or emailed to the appropriate project manager or GIS staff.
4. You can now safely replace the files you just copied with the ones from the original zip file. Right-click the zip archive, and click Extract All. When prompted to Select a folder to extract files to, browse to C:\My Documents\TerraSync. (Figure 5). If prompted about replacing existing files, select Yes to All. Note: It is crucial to make copies of the files first (see Step 3 above)—otherwise, you may lose the data.
5. You should now be able to open the file in Terrasync and begin logging as normal.

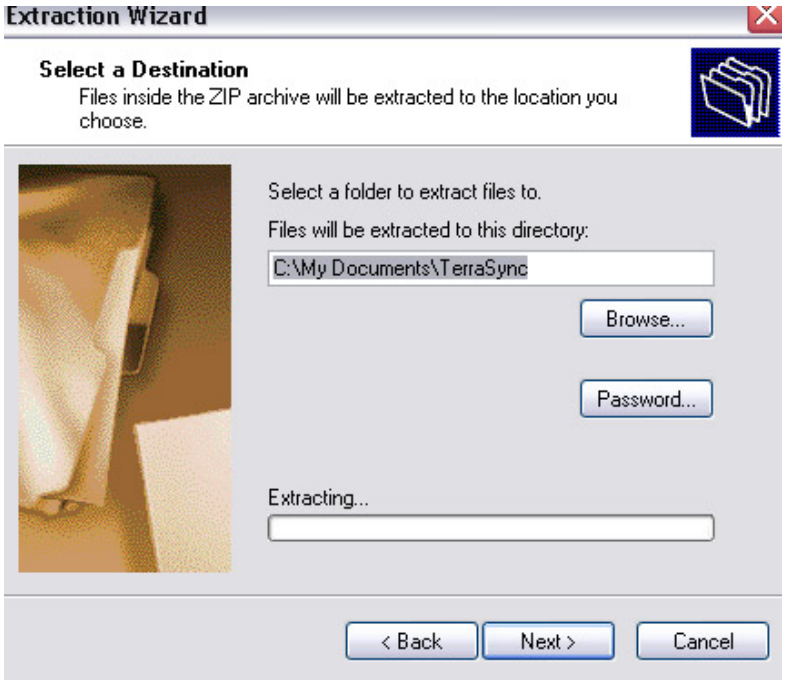

Figure 5. Extract (or copy) Original Target Files into the Terrasync Directory

Option 2: Transfer files back and forth from Terrasync.

If you need to be able to see the previously occupied positions from last week while positioning this week, you need to use Pathfinder to reset the file. This process will essentially combine the targets and actuals from last week into one file. However, this method has its drawbacks; once converted, the actuals from last week will not be able to be corrected, so a backup procedure similar to the one in the previous option should be carried out to maintain data integrity.

The steps for file transfer are as follows:

1. For good data management, back up the data files from the previous week using the procedure laid out in steps 1 through 3 in Option 1 above.
2. Close Terrasync and open up Pathfinder Office.
3. Go to the Utilities>Data Transfer menu or just click the icon on the left (Figure 6).
4. Ensure that the device listed is Terrasync. If not, follow the initial setup instructions at the beginning of this document. Most of the computers used for GPS logging are already setup for this.
5. There are two tabs, Receive and Send. Make sure that Receive is selected and then go to Add>Data File. Select the file(s) that you are using and select Open. The file should now be in the Files to Receive box. Click Transfer All and wait for the transfer to take place. If you have made the recommended backups, it is fine to replace any files.
6. Now select the Send tab (Figure 7), and go to Add>Data File. Select the file you just transferred (it will have the same name as the Terrasync file) and click Open. Now click Transfer All to move the file back to Terrasync.

   By transferring the file back and forth from Terrasync to Pathfinder, you have "reset the clock" and can now update the file for an additional 7 days. This file will have your targets and actual positions from the last week, so it is important to be aware of the features you are selecting for navigation.

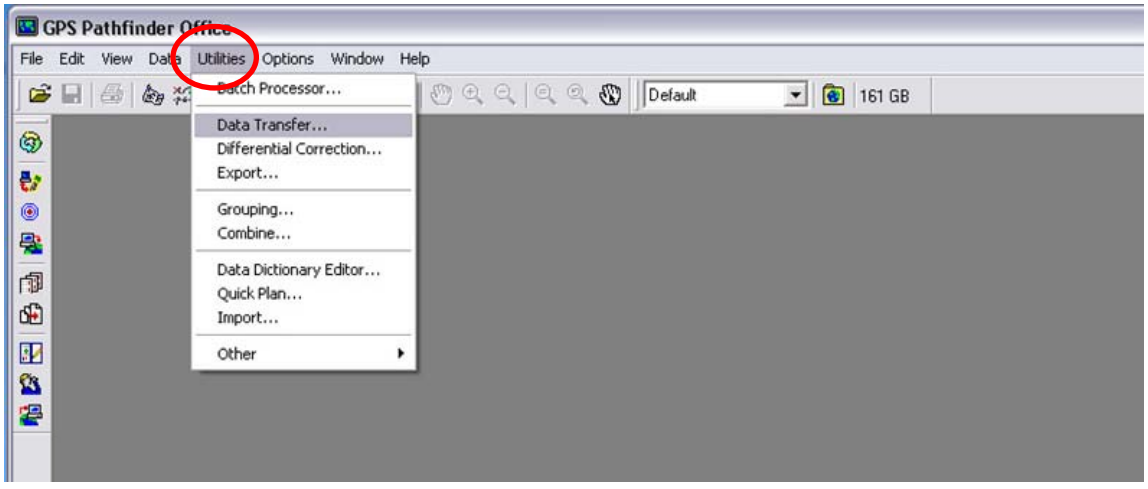

Figure 6. Data Transfer Menu

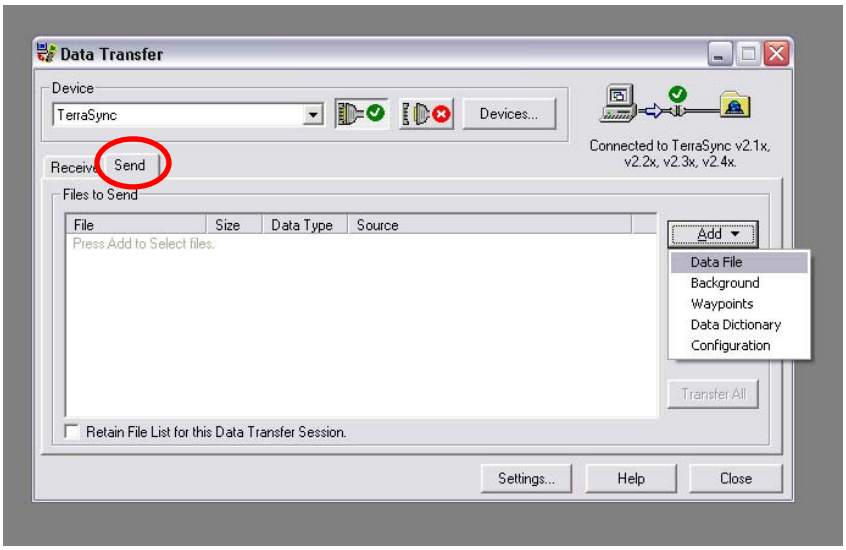

Figure 7. Sending Data File

ATTACHMENT 2
OPERATION MANUALS
AND USER GUIDES

WorkHorse

Monitor, Sentinel, Mariner

Acoustic Doppler Current Profiler

T E C H N I C A L M A N U A L

P/N 957-6150-00 (November 2007)

TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

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WorkHorse Technical Manual

1 Introduction

Thank you for purchasing a Teledyne RD Instruments (TRDI) WorkHorse Broadband Acoustic Doppler Current Profiler (ADCP). This Technical Manual is designed to help WorkHorse users to get familiar with their system.

1.1 How to Contact Teledyne RD Instruments

If you have technical issues or questions involving a specific application or deployment with your instrument, contact our Field Service group:

Teledyne RD Instruments

14020 Stowe Drive
Poway, California 92064

Phone +1 (858) 842-2600

FAX +1 (858) 842-2822

Sales – rdisales@teledyne.com

Field Service – rdifs@teledyne.com

Teledyne RD Instruments Europe

2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Phone +33(0) 492-110-930

FAX +33(0) 492-110-931

Sales – rdie@teledyne.com

Field Service – rdiefs@teledyne.com

Customer Service Administration – rdicsadmin@teledyne.com
Web: http://www.rdinstruments.com
24/7 Technical Support +1 (858) 842-2700

1.2 Getting Started

You are probably eager to get started, but take a moment to read a few words of guidance. We strongly recommend you read *all* of the provided documentation to learn the full capabilities of your WorkHorse.

The WorkHorse Technical Manual includes the following sections:

- **Introduction**. This section is an overview of the WorkHorse system.
- **Installation**. Use this section to plan your installation requirements. This section includes specifications and dimensions for the WorkHorse (including outline installation drawings).
- **Maintenance**. This section covers WorkHorse maintenance. Use this section to make sure the WorkHorse is ready for a deployment.
- **Test**. Use this section to test the WorkHorse.
- **Troubleshooting**. This section includes a system overview and how to troubleshoot the WorkHorse. If the WorkHorse fails a built-in test or you cannot communicate with the system, use this section to help locate the problem.

The User's Guide includes:

- These guides (one for Mariner and Monitor/Sentinel models) contain information on how to use the WorkHorse hardware and software.

The Commands and Output Data Format Guide includes:

- This guide contains a reference for all commands and output data formats used by the WorkHorse. Use the *Command Quick Reference Card* to help remember the direct commands used by the WorkHorse.

The Documentation CD includes:

- The Documentation CD has Adobe Acrobat® Portable Document File (pdf) versions of all the user documentation. Use the electronic documentation to quickly search for information.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Care page (www.rdinstruments.com). Please check our web site often.

1.3 Conventions Used in Manuals

Conventions used in the WorkHorse Technical Manual have been established to help you learn how to use the WorkHorse quickly and easily.

Windows menu items are printed in bold: **File** menu, **Collect Data**. Items that need to be typed by the user or keys to press will be shown as **<F1>.** If a key combination were joined with a plus sign (**<ALT+F>**), you would press and hold the first key while you press the second key. Words printed in italics include program names (*BBTalk*) and file names (*default.txt*).

Code or sample files are printed using a fixed font. Here is an example:

```
WorkHorse Broadband ADCP
TELEDYNE RD INSTRUMENTS (c) 1997-2005
ALL RIGHTS RESERVED
Firmware Version 16.xx
>
```

You will find two other visual aids that help you: Notes and Cautions.

NOTE. This paragraph format indicates additional information that may help you avoid problems or that should be considered in using the described features.

CAUTION. This paragraph format warns the reader of hazardous procedures (for example, activities that may cause loss of data or damage to the WorkHorse).

1.4 WorkHorse Models and Options

The following section explains the different models and options available for WorkHorse ADCPs.

WorkHorse Monitor – The WorkHorse Monitor is designed to measure real-time current profiles from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Monitor ADCP system consists of an ADCP, cables, RS-232-to-RS-422 converter, and software. The Monitor system requires the addition of a Windows® compatible computer to collect data.

WorkHorse Sentinel – The WorkHorse Sentinel is designed for several-month autonomous current profile deployment from temporary or permanent mounting in the ocean, near-shore, harbors, and lakes. The Sentinel ADCP system consists of an ADCP, cables, battery pack, flash memory card, and software. Both battery capacity and memory can be increased with upgrades for longer deployments. The Sentinel can also be used for direct-reading current profile operation. The Sentinel system requires the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

WorkHorse Mariner – The WorkHorse Mariner is designed to measure real-time current profiles from temporary or permanent mounting in a vessel. The Mariner ADCP system consists of a Monitor ADCP with Bottom Track mode, cables, Deck Box, Mounting Plate, and software. The Mariner system requires the addition of a Windows® compatible computer to collect data.

WorkHorse Options

- **Bottom Track** – You can use your WorkHorse ADCP from moving boats and ships with the Bottom Track Upgrade. Once the Bottom Track Upgrade is added, a WorkHorse ADCP can measure both water depth and boat velocity over the ground.
- **Shallow Water Bottom Track Mode 7** – You can use your WorkHorse 1200kHz ZedHed™ ADCP in water as shallow as 30cm.
- **High-Resolution Water Profiling Modes** – This upgrade allows you to collect water profiles using Water Modes 1, 5, 8, and 11.
- **High Ping Rate Water Mode** – This upgrade allows you to collect water profiles using Water Mode 12.
- **Waves** – This upgrade allows you to use the ADCP as a wave gauge.
- **External Batteries** – Adding external batteries can increase the deployment length for Sentinel ADCPs. Use an External Battery with a Monitor ADCP to provide backup power or for self-contained deployments.
- **High-Pressure Housing** – The standard WorkHorse housing allows deployment depths to 200 meters. High-pressure housings are available in depth rating of 500, 1000, 3000, and 6000 meters. See the "Outline Installation Drawings," page 157 for dimensions and weights.
- **Memory** – The WorkHorse Sentinel ADCP includes one memory card. Two PCMCIA memory card slots are available for all WorkHorse ADCPs (see "PC Card Recorder," page 66 for memory card specifications). The maximum memory for each slot is 1GB, with the total memory capacity not to exceed 2GB.
- **Spare boards kit** – Contains a complete set of spare printed circuit boards for a WorkHorse ADCP. The set does not include boards purchased as options such as the gyro/synchro board or the receiver board (not field replaceable).

- ***VmDas* Software** – Controls the ADCP and displays profile data through a personal computer.
- ***WinRiver* Software** – Controls the ADCP and displays discharge data and profile data through a personal computer.
- ***Waves* Software** – Controls the ADCP and displays waves data through a personal computer.

Mariner Options

- **Deck Box** – Converts AC power input or 12 VDC input into 48 VDC output for the Mariner input power. Converts computer RS232 to RS422. Option: converts gyro analog input to a serial NMEA output (requires an optional gyro interface; must be purchased at time of order).
- **Gyrocompass (Gyro) Interface** – Connects the ship's gyro to the Deck Box (must be purchased at time of order).
- **Mounting Plate** – A bronze plate that helps mount the transducer head to a vessel. See the "Outline Installation Drawings," page 157 for dimensions.

1.5 WorkHorse Care

This section contains a list of items you should be aware of every time you handle, use, or deploy your WorkHorse. *Please refer to this list often*.

1.5.1 General Handling Guidelines

- Never set the transducer on a hard or rough surface. **The urethane faces may be damaged.**
- Always remove the retaining strap on the underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**
- Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the connector may cause the ADCP to flood.** Read the Maintenance section for details on disconnecting the I/O cable.
- Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks.** Cover the transducer faces on the WorkHorse if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle.** Cover the connector on the WorkHorse if it will be exposed to sunlight.

- Do not store the ADCP in temperatures over 60 degrees C with the batteries removed. **The urethane faces may be damaged.** Check the temperature indicator inside the shipping case. It changes color if the temperature limit is exceeded.
- Store batteries in a **cool dry location** (0 to 21 degrees C). If the batteries are installed in the ADCP, do not store the ADCP in temperatures over 21 degrees C.
- Do not store batteries inside the ADCP for extended periods. **The batteries may leak.**
- Use batteries within one year. **Batteries stored for more than 12 months should NEVER be used!**
- Vent the system before opening by loosening the hardware on the housing. **If the ADCP flooded, there may be gas under pressure inside the housing.**
- Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the ADCP to flood.** Do not risk a deployment with damaged O-ring surfaces.
- Do not lift or support a WorkHorse by the external I/O cable. **The connector or cable will break.**

1.5.2 Assembly Guidelines

- Read the Maintenance section for details on WorkHorse re-assembly. Make sure the housing assembly O-ring stays in the groove when you re-assemble the WorkHorse. Tighten the hardware as specified. **Loose, missing, stripped hardware, or a damaged O-ring can cause the WorkHorse transducer to flood.**
- Place a light amount of DC-111 lubricant on the connector pins (rubber portion only). **This will make it easier to connect or remove the I/O cable and dummy plug.**
- Do not connect or disconnect the I/O cable with power applied. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn.**
- The **WorkHorse** I/O cable is *wet* mate-able, not *under water* mate-able.

1.5.3 Deployment Guidelines

- Read the WorkHorse User's Guide and the Software User's Guides. **These guides have tutorials to help you learn how to use the ADCP.**
- WorkHorse Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal** the ADCP before deployment.
- Align the compass whenever the batteries are replaced, the recorder module is replaced, or when any ferrous metals are relocated inside or around the WorkHorse housing. **Ferro-magnetic materials affect the compass.**

NOTE. When the batteries are changed the compass must be calibrated with the AF command (see "Compass Calibration," page 58).

- The AC power adapter is not designed to withstand water. **Use caution when using on decks in wet conditions.**
- Avoid using ferro-magnetic materials in the mounting fixtures or near the WorkHorse. **Ferro-magnetic materials affect the compass.**

1.6 System Overview

The WorkHorse ADCP system consists of an ADCP, cables, battery pack, flash memory card, and software. Both battery capacity and memory can be increased with upgrades for longer deployments. The WorkHorse can also be used for direct-reading current profile operation. They only require the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

The transducer assembly contains the transducer ceramics and electronics. The standard acoustic frequency is 150kHz. See the outline drawing for dimensions and weights.

I/O Cable Connector – Input/Output (I/O) cable connects the WorkHorse ADCP to the computer and external power supply.

Beam-3 Mark – The Beam-3 mark shows the location of Beam-3 (Forward).

Urethane Faces – The urethane faces covers the transducer ceramics. Never set the transducer on a hard surface. The urethane faces may be damaged.

Housing – The standard WorkHorse housing allows deployment depths to 200 meters.

Thermistor – The Thermistor measures the water temperature.

Pressure Sensor – The pressure sensor (standard 200 Bar) measures water pressure (depth).

Transducer Head – The WorkHorse electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicate the beam number. When assembling the unit, match the transducer beam number 3 with the Beam 3 mark on the end-cap.

End-Cap – The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.

Internal Battery Pack – The Sentinel ADCP includes an alkaline battery. The internal battery pack has 450 watt-hours (Wh) of usable energy at 0 C. When fresh, the voltage is +42 VDC. When depleted, the voltage drops to 30 VDC or less.

Flash Memory Card – WorkHorse Sentinel ADCPs come standard with one memory card. Two PCMCIA memory cards slots are available, with the total memory capacity not to exceed 2GB.

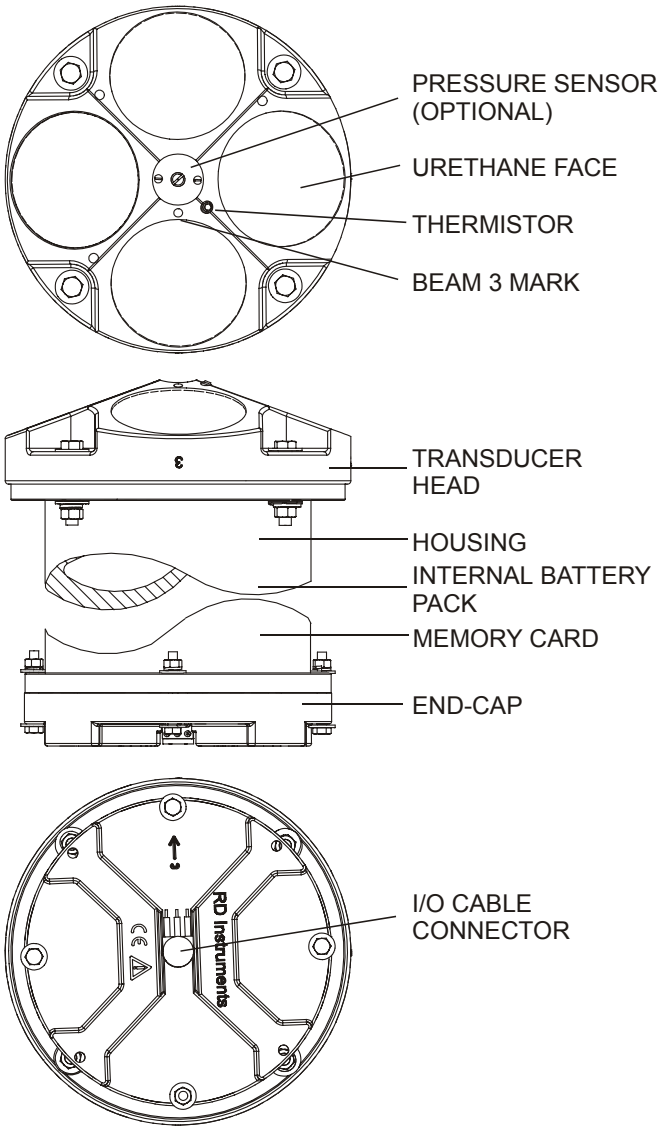

Figure 1. WorkHorse Sentinel ADCP Overview

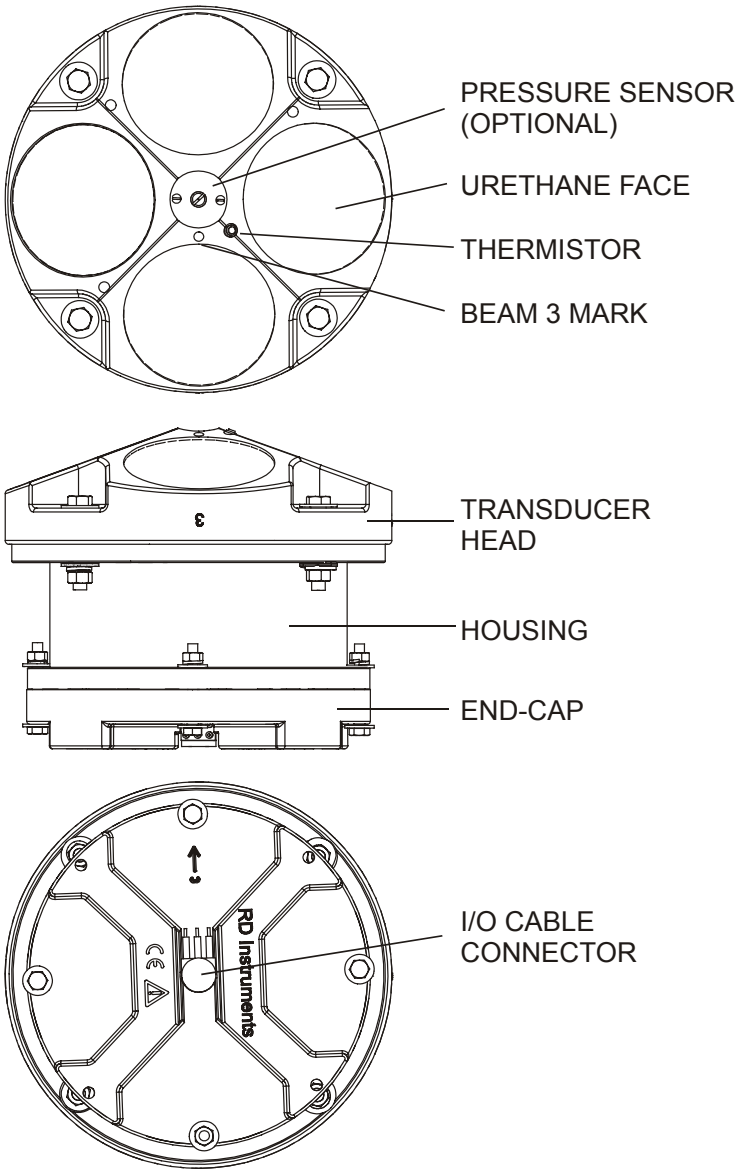

Figure 2. WorkHorse Mariner/Monitor ADCP Overview

1.7 Unpacking

When unpacking, use care to prevent physical damage to the transducer face and connector. Use a soft pad to protect the transducer. When handling any electronics modules, follow electrostatic discharge (ESD) prevention measures.

1.7.1 Inventory

You should have the following items.

- ADCP transducer
- I/O cable
- AC power adapter (Monitor and Sentinel only)
- Deck Box and mounting plate (Mariner only)
- Ship Kit (includes manuals, software, and power cords)
- Shipping crate (please save all foam for reshipping use)

1.7.2 Visual Inspection of the WorkHorse

Inspect the WorkHorse using the following table and Figure 3 and Figure 4, page 12. If you find any discrepancies, call TRDI for instructions.

Table 1: Visual Inspection Criteria

Item	Inspection Criteria
Transducer	Check the urethane face. There should be no gouges, dents, scrapes, or peeling (see Figure 3).
I/O connector	Check the I/O connector for cracks or bent pins (see Figure 4, page 12).
I/O Cable	Check the cable connectors for cracks or bent pins.
Deck Box (Mariner only)	Check the connectors on the rear panel for cracks or bent pins.

Figure 3. WorkHorse Transducer Face View

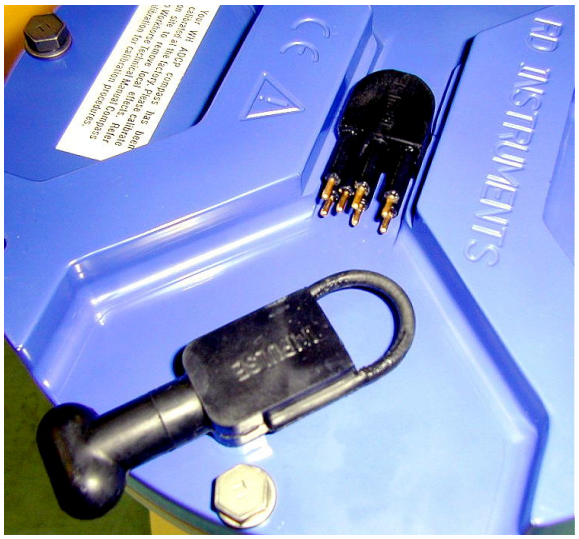

Figure 4. WorkHorse End-Cap Connector View

NOTE. Refer to the appropriate ADCP User's Guide for instructions on how to connect and use the ADCP.

2 Installation

This section is a *guide* for installing the WorkHorse on a buoy or bottom mount. Use this section to plan your installation layout.

CAUTION. Always use caution when mounting the WorkHorse. Never rest the transducer head on a rough surface. Use foam padding to protect the transducer during handling.

2.1 Bottom Mounts

Bottom mounts can range from simple PVC frames to Trawl Resistant Bottom Mounts. Below is a sample of some of the types of bottom mounts available for WorkHorse ADCPs.

Figure 5. Teledyne RD Instruments Bottom Mount

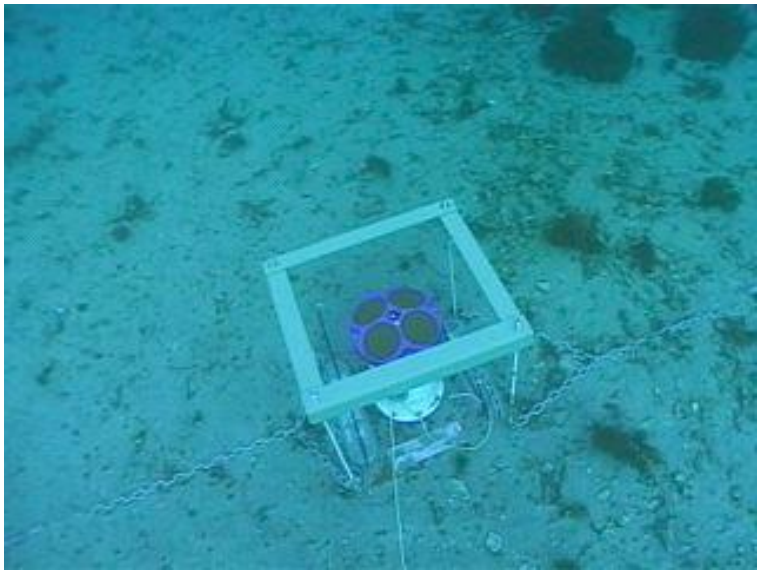

Figure 6. View from the Bottom

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

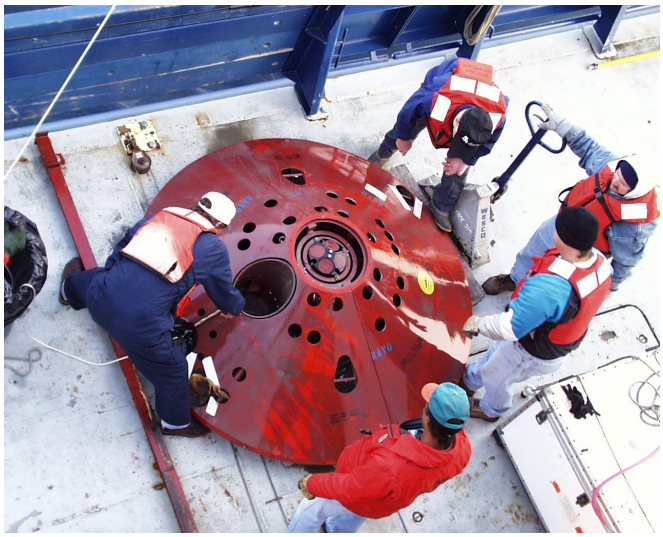

Figure 7. Trawl Resistant Bottom Mount

Photo courtesy of Maureen Wieler, Mooring Systems.

2.2 Buoy Mounts and Load Cages

Buoy mounts and load cage frames are designed to allow the Workhorse to profile unobstructed by the mooring hardware. Below is a sample of some the types of buoy and load cage mounts available for WorkHorse ADCPs.

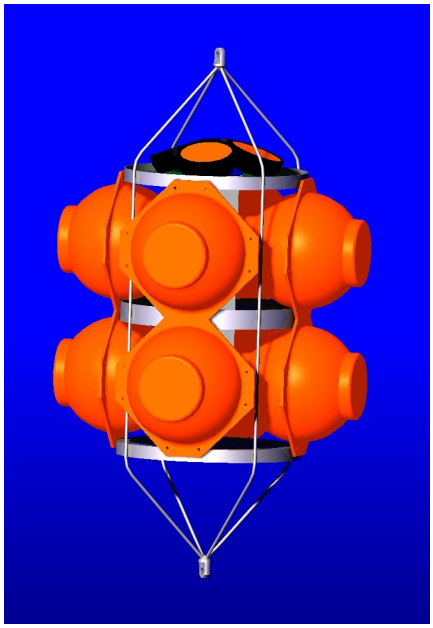

Figure 8. Deep-Water Mount

Photo courtesy of the Oceanscience Group.

Figure 9. Buoy Mount with External Battery

Photo courtesy of Maureen Wieler, Mooring Systems.

Figure 10. Subsurface Buoy

Photo courtesy of Patrick Lefeuvre, Technicap. The Subsurface buoy was developed by BMTI and Technicap.

Figure 11. Buoy Mount

Photo courtesy of Flotation Technologies.

Figure 12. Load Cage

Photo courtesy of Angela Cates, UNM.

2.3 Over-the-Side Mounting

The over-the-side mount is common if you want the ability to move the ADCP from one platform to another. You must make the mount as rigid as possible to limit the amount of pitch and roll applied to the ADCP. Although the tilt sensor can measure a ±20° influence, anything beyond 15° will cause bias to the data that cannot be removed. No matter what mounting type used, the ADCP must be below the bubble layer. Bubbles will cling to the urethane faces of the ADCP and reduce the range to almost nothing. Usually a mount somewhere aft of amidship is used. A stern mount will cause all sorts of problems due to propeller wake, bubbles, and turbulent water conditions.

NOTE. Avoid using ferro-magnetic materials in the mounting fixtures or near the ADCP. They affect the compass. Use 304 stainless steel for fresh water and 316 stainless steel for salt-water applications.

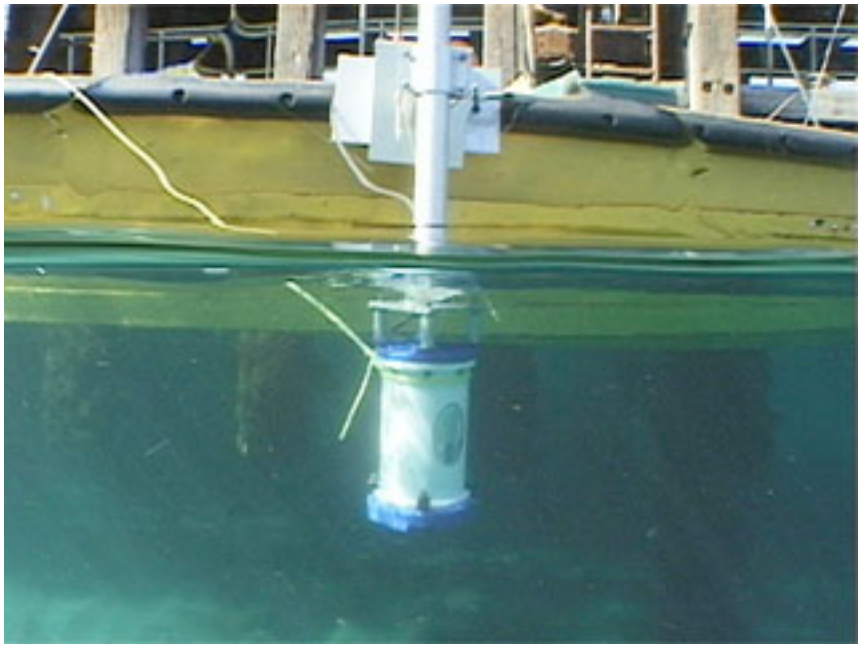

Figure 13. Over-the-Side Mount

Photo courtesy of John Skadberg, US Navy SPAWAR System Center in San Diego, CA. Sent to TRDI by Steve Monismith.

2.3.1 Floating Objects

Our transducer assembly is sturdy, but we did not design it to withstand collisions with all floating objects. We strongly suggest you use the in-hull mount (see "In-Hull Mounting," page 18) if this is a possibility.

2.3.2 Example of an Over-the-Side Mount

When mounting the ADCP to a platform, use the following sequence.

- Test the ADCP
- Align the compass
- Mount to the platform (see Figure 14).

1. Hand winch with cable or rope.
2. Boat cleat to tie off the lower end of the channel.
3. Aluminum channel, 5" base x 2" high x 3/16" thick. You need to determine how long the channel needs to be as the drawing is not to any scale. The channel should be notched for the end-cap flange of the Housing Assembly. This will give the system a positive lock after the ADCP has been strapped to the channel.
4. Pivot housing - This could be a very heavy one-piece bent housing, or a three-piece assembly. Bolt the pivot housing to the deck of the boat (or buoy).
5. Nylon strap clamps - Two clamps are needed. Place some rubber or foam between the housing and the aluminum channel before clamping to protect the ADCP.

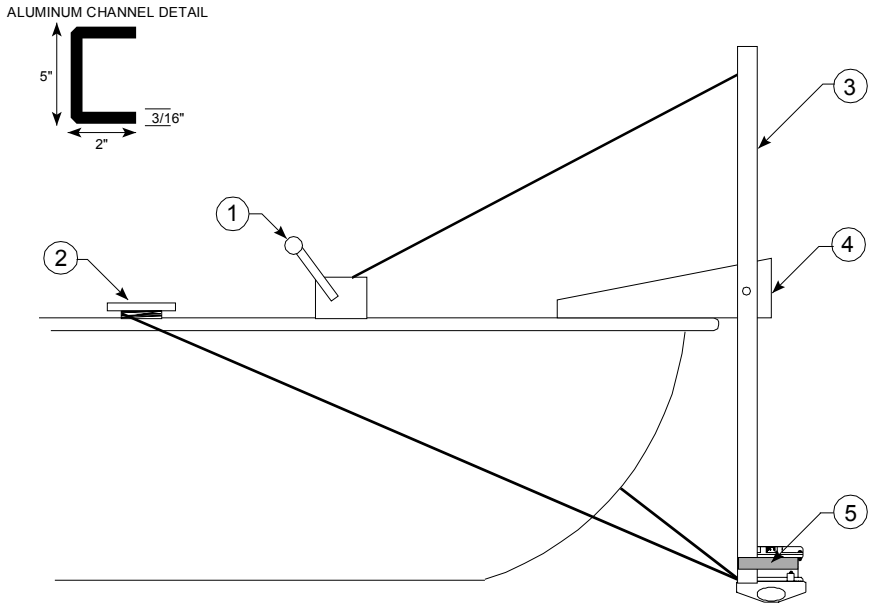

Figure 14. Mounting an ADCP to a Platform

2.3.3 Over-the-Side Mounting Special Considerations

Use the following suggestions when mounting the ADCP to a platform.

- It is desirable to rigidly mount the ADCP to the platform. You want to avoid the free spinning of the ADCP in this application. The ADCP must stay in the water at all times.
- The ADCP must be mounted deep enough so that turbulence caused by its movement through the water does not allow air bubbles to be attached to the transducer faces.
- Avoid mounting the ADCP near motors and thrusters. They cause air bubbles and will cause bias to the internal compass.
- Avoid mountings that will cause the ADCP to see severe accelerations.

2.4 In-Hull Mounting

The in-hull mounted ADCP is common when it is intended to keep the system on a single vessel or when over-the-side mounting is not practical for your vessel. For this type of mounting, there are issues of beam clearance and access.

2.4.1 Transducer Head Mounting Considerations

You must consider several potential problems before installing the transducer head assembly. Read this section before deciding where to install the transducer assembly. See the outline installation drawings for specifications on our standard ADCP transducer heads.

2.4.2 Location

Ideally, you want to install the transducer head:

- Where it is accessible both internally (for access to transducer electronics) and externally (to remove biofouling).
- Away from shipboard protrusions that reflect ADCP energy. Allow for a reflection-free clearance of 15° around each beam (see the outline installation drawings).
- Away from other acoustic/sonar devices, especially those operating at the same frequency (or harmonic) of the ADCP.
- Close to the ship's fore-to-aft centerline. As distance from the centerline increases, vertical accelerations caused by the roll of the ship also increase. These accelerations can cause additional uncertainties in ADCP velocity measurements.

Other considerations may be:

- Ease of installation.
- Portability (wanting to move the instrument from vessel to vessel).
- Permanent installation.

With all of these choices there are good and bad points. We will show you several options for installation and then go through specific concerns that you may have to deal with once you install or mount the ADCP.

2.4.3 Sea Chest In-Hull Mounting

A sea chest (Figure 15 and Figure 16, page 20) is a fixture that surrounds and holds the transducer head, protecting it from debris in the water. The bottom of the sea chest must be open to seawater to allow the acoustic beams to pass through freely. If using a sea chest interests you, call us for the latest information. Ask for Application Note 7 - Conceptual Design of a Sea Chest for a TRDI ADCP Transducer (also available on our web site at www.rdinstruments.com).

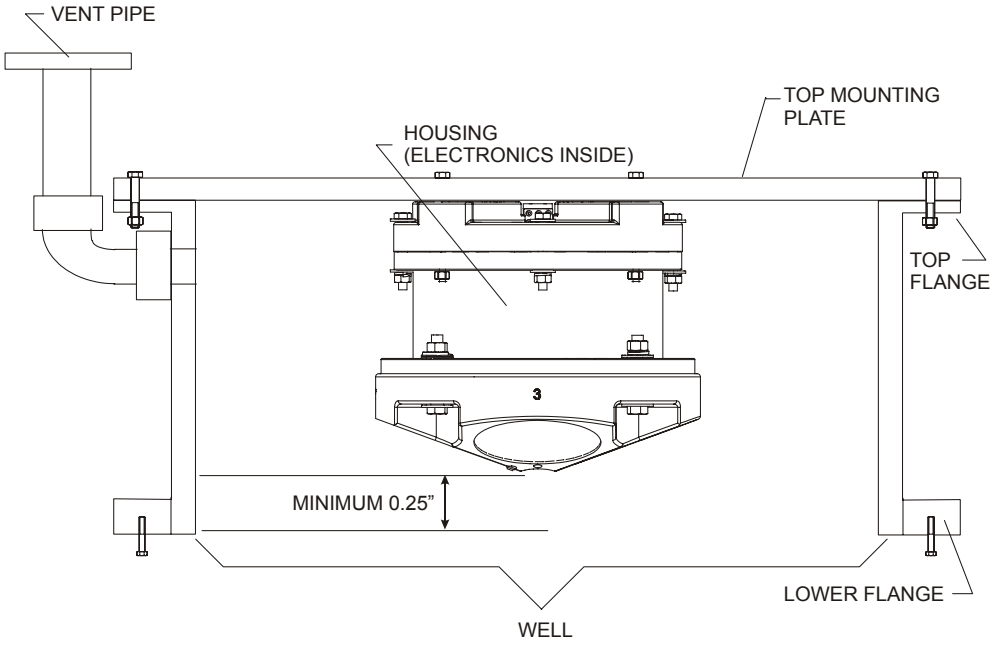

Figure 15. Sea Chest Mounted Transducer (Without an Adapter Plate)

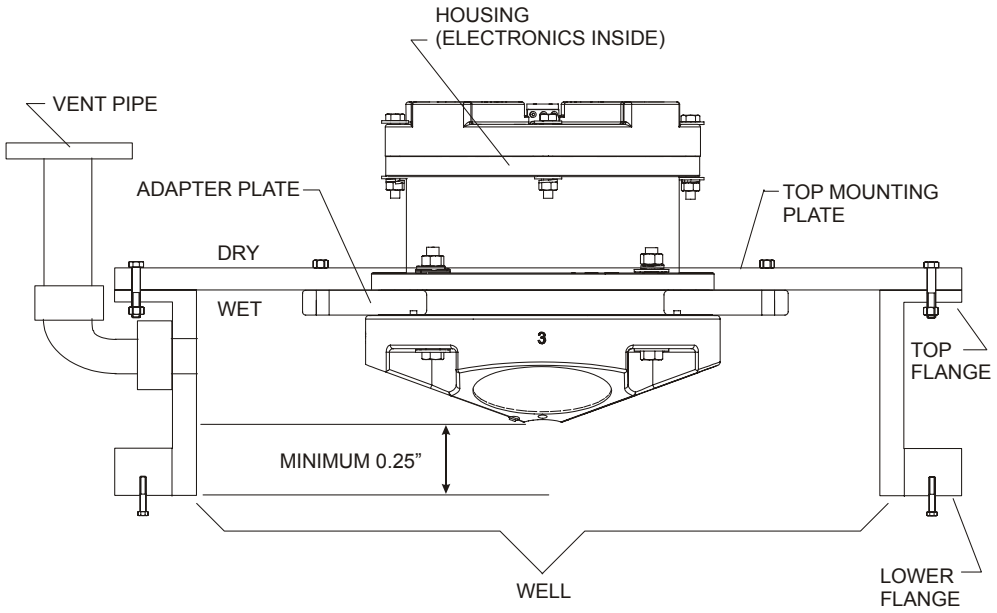

Figure 16. Sea Chest Mounted Transducer (With Mariner Adapter Plate)

NOTE. For instructions on how to install the Mariner Adapter Plate, see "Mariner Adapter Plate," page 52.

2.4.4 Mounting Considerations

Now that we have shown you the main methods of mounting the ADCP, you must be aware of issues that may cause reduction in range, biased data, fouling, and other performance related considerations.

Orientation

We recommend you mount the transducer head with Beam 3 rotated to a ship-relative angle of 45° (Figure 20, page 44 shows beam orientation). This causes the magnitude of the signal in each beam to be about the same. This improves error rejection, reduces the effect of ringing (see "Acoustic Isolation," page 26), and increases the ADCP's effective velocity range by a factor of 1.4. If you align Beam 3 at an angle other than zero, you must nullify this offset. You can do this using a direct command (see the Workhorse Technical Manual) or through our *VmDas* program.

Use the ship's roll and pitch reference to mount the transducer head as level as possible. If the head is not level, depth cell (bin) mapping will be incorrect. Large misalignments can cause large velocity measurement errors. If you cannot mechanically make the transducer head level, you can use *VmDas* to enter offset values for roll and pitch.

Fairing

A fairing is a structure that produces a smooth outline and reduces drag or water resistance. The fairing also diverts floating objects away from the transducer. A fairing that is shaped like a teardrop, slopped such that the leading edge (closer to the bow) is higher than the back edge, and extends below the hull (typically 12 inches) will divert the air bubbles away from the transducer faces.

Acoustic Window

While we do not fully understand windows, we do believe that windows can be used to produce overall performance improvements in vessel-mounted ADCPs. Additionally, if the ship operates where there is danger of barnacle damage or a high density of ice or other floating objects, then the use of an acoustic window is the only option.

It is theoretically possible to use a window successfully, however there are several advantages and disadvantages to consider before using an acoustic window.

Advantages

- Well will not fill with air bubbles caused by the ship moving through the surface water, see "Sea Chest In-Hull Mounting," page 19
- Flow noise is reduced, see "Flow Noise," page 25.
- The well can be filled with fresh water to limit corrosion.
- Barnacles can not grow on the transducer faces. Barnacle growth is the number one cause of failure of the transducer beams.
- The transducer is protected from debris floating in the water.

Disadvantages

- The range of the ADCP will be reduced because the window can and will absorb some of the transmit and receive energy.
- The transmit signal could be reflected into the well, causing the well to "ring" like a bell. This will cause the data being collected during the ringing to be biased. Some ships have reported a loss in range as great as 50 meters. The ringing may be dampened by applying sound absorbing material on the well walls (TRDI does not have any recommendations for sound absorbing material), see "Ringing," page 25.
- The transmit signal could be reflected off the window and back into the other beams.

Our experience has allowed us to put together some minimum specific recommendations:

Window orientation. The acoustic window should be flat and parallel to the transducer mounting plate. Note this is not an absolute requirement. However, if the water temperatures inside the window and outside the window are not the same, all four beams will be refracted and actual velocity components will be rotated into a new coordinate system. In particular, some of the horizontal velocity will appear as a vertical velocity.

Window material. Important acoustic properties of the window include acoustic refractive index (which should be as close as possible to that of water), insertion loss (which should be as small as possible) and speed of sound. There are two acoustic refractive indices: one for shear waves and one for plane waves. The acoustic refractive indices are simply the ratios of speed of sound in water to speed of sounds in the material. Insertion loss combines absorption and reflection of sound, and it depends on both the thickness and the material properties of the window. In particular, you should avoid using window thickness equal to odd multiples of shear mode quarter-waves (Dubbelday and Rittenmeyer, 1987; Dubbleday, 1986). Refer to Selfridge (1985) and Thompson (1990) for more information. Note that the speeds of sound in plastics decrease with increasing temperature and that causes the resonant frequencies to shift. This can be a large effect. Neither Selfridge nor Thompson has much information on the temperature coefficients of sound speeds.

Our experience has shown that Polycarbonate windows are very good for the Ocean Surveyor/Observer (OS), WorkHorse (WH), and Broadband (BB) ADCPs. The thickness of the materials depends on the frequency you intend to use. Table 2 will help to choose the maximum thickness you should use.

NOTE. One concern with window selection is that it be able to support the weight of the water inside the well once the ship is dry-docked. TRDI recommends that you always fill/drain the well at the same time that you are either filling/draining the dry dock area.

Table 2: Window Thickness

Frequency	Recommended Thickness	Maximum Thickness
75	1 inch	2 inches
300	0.5 inches	1 inch
600	0.25 inches	0.5 inches
1200	0.25 inches	0.5 inches

Spacing between window and transducer. The primary geometrical factor in design of windows is the reflection of one beam into another beam, causing crosstalk between the beams. The distance from the window should be at least 0.25 inches and no more than 0.5 inches for optimal setup.

Window aperture. The window aperture must be sufficient to pass the beams without causing diffraction. If the window is placed next to the transducer, then the aperture diameter should be the same as the distance between transducer cup corners. If the window is placed away from the transducer, then the aperture should be larger than all four beams plus about one transducer ceramic diameter.

Free Flow and Windows

If filling and draining the well is an issue, then you may want to use a window but allow the water to freely exchange from outside the well to inside the well.

Our Japanese representative uses 0.25 inch thick Low Density Polethylene (LDPE). He then drills two 30mm holes in the window along the edges. The inside walls are painted with anti-fouling paint. This allows the water to be full of anti-foulant during the time the ship is docked, which is when the barnacle growth occurs. The holes allow the water to exchange when the ship is in motion and allows for draining when the ship is dry-docked (a 0.25" window will not support the weight of the water). He has never had a failure with the window, and has seen only a minimal loss in range (5-30 meters).

It is best if the window is parallel to the bottom edge of the transducer cups. The transducer cups are at a 30° angle. If the window is at an angle to the transducer, it will change the absorption. We do not have experience with different angles, but we have had customers use domes or have the window follow the contour of the ship bottom without real problems.

The optimum distance for the bottom of the transducer assembly from the window is 0.25 inches ±0.125 inches. Never allow the transducer to touch the window. The farther away the transducer cups are from the window, the more the sound is reflected off of one beam and then reflected into another beam.

Acoustically-absorbing sea chest liner. A sound absorbing material should be used inside the sea chest to minimize the effects of sound ringing within the sea chest. The material should be a minimum of one wavelength thick (include the sound speed of the absorbing material when calculating the size of a wavelength). Approximate wavelengths of sound in seawater are given below in Table 3, page 24. We do not have sufficient experience to recommend a specific absorbing material.

Table 3: Wavelength of sound in seawater (1500 m/s sound speed)

FREQUENCY (kHz)	WAVELENGTH (mm)
75	20
300	5
600	2.5
1200	1.25

Fluid in the sea chest. The sea chest should be filled with fresh water. Seawater can be used, but at the cost of increased corrosion. Seawater should not be circulated through the sea chest because it will encourage growth of biofouling organisms. The pressure within the sea chest should be adjusted to keep the window from bowing in and out, and thereafter, the volume should be kept constant.

Transducer calibration. The factor used to correct velocity for speed of sound variations should be based on the speed of sound of the fluid inside the sea chest. Changes of speed of sound resulting from temperature changes may be computed from the temperature sensor on the transducer.

Air Bubbles

Design your installation to minimize the volume of air bubbles in the path of the acoustic beams. Air bubbles attenuate (weaken) the signal strength and reduce the ADCP profiling range. Ships with a deep draft or a non-flat bottom have fewer problems with bubbles. Ways to reduce bubble flow vary with ship characteristics, but two options are available. Mount the transducers below or away from the bubble layer.

- The flow layer is usually within the first two feet below the hull. Bubbles can get trapped in this layer. Mounting the transducer head amidship on the fore-to-aft centerline may help. For ships with propulsion systems that make large amounts of bubbles, use a mounting technique that lets you lower the transducer head below the hull while underway.

NOTE. If you use locally made or existing extension hardware instead of the hardware available from TRDI, you may need to make an adapter plate to connect your hardware to our transducer head. Please call us for the exact dimensions and layout of our transducer head bolt holes for your system.

- Divert the bubble layer so it flows around the transducers - You can use fairings to alter the bubble flow. An acoustic window (see "Acoustic Window," page 21) may help reduce the bubble problem, but can cause ringing (see "Acoustic Isolation," page 26) and attenuation problems.

Flow Noise

Water flowing over the transducer faces increases the acoustic noise level, which decreases the profiling range of the ADCP. You can reduce the flow across the transducer faces with a sea chest, fairing, or acoustic window.

Corrosion and Cathodic Disbondment

Your ADCP is made of plastic and uses titanium bolts. The adapter plate (if used) may be naval bronze, aluminum, or other materials. Although the plastic ADCP will not corrode, the bolts and adapter plate may corrode.

Never attach anodes directly to the transducer head. Standard anode protection used for the ship should be installed outside of the well of the transducer head. Mounting of ship's standard anode protection outside of the transducer well will typically protect the parts that may corrode. However, you should plan regular inspections of mounting hardware and the adapter plate for signs of corrosion. Replace and parts that are questionable (corrosion can be further reduced if the well is covered with a window and then filled with fresh water).

Ringing

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water.

As stated, the main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in either the water or the well.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing."

If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. The typical ringing period for each ADCP frequency is as follows; 75kHz is 8 meters, 300kHz ADCPs is 2 meters, 600kHz ADCPs is 1.5 meters, and 1200kHz ADCPs is 0.8 meters. These typical ringing values

are recommended as the minimum setting for all ADCPs using default set-ups.

It should be noted, on some installations the effects of ringing will last longer than the recommended settings above. For example, the effects of ringing will last longer if the transmit signal becomes trapped inside the transducer well. This can occur because the well itself is ringing with the transducer or when windows covering the opening of the well reflect the signal back inside the well.

The window causes the transmit signal to reflect back into the well due to the difference in impedance between the window and the water. When the transmit signal is reflected in the well it becomes trapped and this results in longer ringing periods. To keep from processing this signal, the blanking period must be increased.

Lining the inside walls of the well with a sound absorbing material aid in dampening the ringing effect.

Acoustic Isolation

Try to minimize the acoustic coupling between the transducer head and the ship. Without adequate acoustic isolation, the transducer output will "ring" throughout the ship and feeds back into the ADCP receive circuits. Ringing causes bias errors in water-track velocities and results in the loss of data in the closest depth cells (bins). Reflections inside a sea chest with an acoustic window also can cause ringing.

You can attain acoustic isolation several ways. At a minimum, use gaskets to isolate all contact points between the ship and the transducer head. Design your installation for:

- A minimum number of contact points between the transducer head and the ship.
- Minimal contact area.
- Single points of contact for positioning and support (when possible).

You also should try to separate the transducer head from the ship using intermediate connections. This is because direct connections transfer the most acoustic energy. Texas A & M used the following installation technique and had minimal ringing problems.

- Transducer mounted to a thin steel plate
- Steel plate positioned with three pins set into mounting holes on the hull; pins isolated with gaskets
- Steel plate held in place with four I-beams welded to a frame

- Frame bolted to another frame and separated by gaskets
- Second frame bolted to the ship and separated by gaskets

Acoustic isolation from other acoustic devices on the ship is also necessary. You can do this using the following techniques.

- Mount the other acoustic devices as far apart as possible.
- Make sure neither the main lobes nor the side lobes of the acoustic devices point at the transducers, including acoustic reflections.
- Try not to operate devices that use the same frequency or a harmonic of the ADCP's frequency.

Maintenance

"Maintenance," page 45 explains routine maintenance procedures. You rarely need access to the electronics inside the transducer head. However, one external maintenance item is important enough to mention here as it may affect how you install the transducer head.

Objects deployed within about 100 meters (328 feet) of the surface are subject to the buildup of organic sea life (biofouling). This means WorkHorse ADCPs are subject to biofouling. Soft-bodied organisms usually cause no problems, but hard barnacle shells can cut through the urethane transducer face causing transducer failure and leakage into the ADCP (see Figure 17).

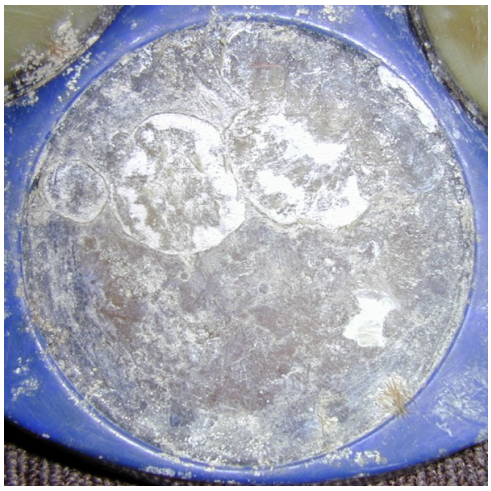

Figure 17. Barnacle Damage to Urethane Face

The best-known way to control biofouling is cleaning the ADCP transducer faces often. However, in many cases this is not possible. The other alternatives include the use of a window or some sort of anti-foulant protection.

Some of our users have had success applying a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and Vaseline or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.

Some organizations may decide to use antifouling grease. However, most antifouling greases are toxic and may cause problems. Recent tests suggest antifouling grease may cause the urethane on the transducer faces to develop cracks. Warmer temperatures accelerate this effect.

The other method is to use antifoulant paint (see "Applying Antifouling Paints," page 70).

CAUTION.

1. Read the Material Safety Date Sheet before using any of the listed solvents and paints.
2. Some antifouling coatings may not be legal for use in all areas. Check with your local environmental agency before using the antifouling paint.
3. Do not arbitrarily use antifouling paints. Be aware that antifouling paints can accelerate the dezincification corrosion of brass. Once initiated, dezincificatioin will rapidly destroy the brass.
4. TRDI no longer recommends the use of Nopcocide for the prevention of biofouling. If using antifouling grease, remove it immediately after recovering the ADCP.
5. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
6. When possible, do not coat the transducer faces with cuprous oxide or related paints that contain chemicals such as copper, chrome, or arsenic. These paints advance the corrosion of the transducer assembly and will cause the urethane to separate from the transducer cups.
7. All US Coastal States prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.

Mariner Deck Box Mounting Considerations

Place the Mariner Deck Box (see "Outline Installation Drawings," page 157) where there is access to the I/O cable, host computer, gyro interface cable, and navigation interface cable. The chassis needs an input voltage of 90 to 260 VAC or 12 VDC to operate (see "Power Considerations," page

40). Allow enough room around the Deck Box for access, ventilation, and isolation from electronic and magnetic interference.

2.4.5 Cabling Considerations

Several cables connect to the ADCP system (see Figure 18). Use care when routing these cables through bulkheads, deck plates, cable runs, and water-tight spaces. Make allowances in cable length and engineering design plans for cable routing. When necessary, use strain reliefs on the cables.

The input/output (I/O) cable connects the transducer head to the deck box (Mariner systems) or computer. We deliver the cable with both connectors attached. The transducer-end connector is molded on, so you can use it below the waterline. The cable is custom-made in lengths specified by the user. Route this cable so:

- You can install it with the connectors attached.

NOTE. You can order the cable with the chassis-end connector removed. This allows easier cable routing, but requires you to solder the cable connections at your installation site. This is a difficult task.

- It does not have kinks or sharp bends.
- You can easily replace it if it fails.
- The dry-end connector OD is 5.02cm (1.530 inches) and is 3.89cm (1.976 inches) long. Model# Souriau 85106RC2024P50.
- The wet-end connector is 3.0cm (1.18 inches) long, 2.54cm (1.00 inches) wide, 1.27cm (0.5 inches) high. Model# Impluse LPMIL-7-FS.

Other cables that may need routing to the chassis include the computer interface, the navigation interface, and the gyro interface.

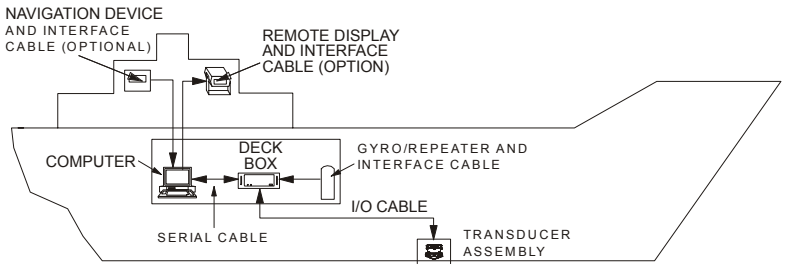

Figure 18. Typical Mariner Interface Cable Layout (Overview)

NOTE. See the appropriate ADCP User's Guide for a detailed view of the cable connections.

2.5 Computer Considerations

We designed the WorkHorse ADCP to use a Windows® compatible computer. The computer controls the ADCP and displays its data, usually through our *WinSC*, *WinADCP*, *VmDas* or *WinRiver* programs. Table 4 lists the minimum computer requirements.

NOTE. It is highly recommended that you download and install all of the critical updates, recommended updates, and the service releases for the version of Windows® that you are using prior to installing any TRDI software.

Table 4: Minimum Computer Hardware Requirements

Windows® XP or Windows® 2000
Pentium III 400 MHz class PC (higher recommended)
64 megabytes of RAM (128 MB RAM recommended)
10 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended
One Serial Port (two or more High Speed UART Serial Port recommended)
Minimum display resolution of 1024 x 768, 256 color (higher recommended)

NOTE. VmDas has special requirements – see the VmDas User's Guide for detailed information on system requirements.

The computer configuration varies depending of the number of communication ports and the external data refresh rate. Serial communications require a lot of processor resources, and the minimum requirements can vary. A good quality video card is required to operate *VmDas* and *WinADCP* simultaneously. We do not use graphic card 3D functions, however, video memory is needed to display all graphics.

However, with experience we can recommend that:

- If you are using more than two communication ports, you should not use a Celeron processor.
- Intel Pentium III processors work best to operate the ADCP and give access to the display and keyboard without losing ensembles.

2.6 Gyrocompass Interface Considerations

NOTE. The Gyrocompass Interface is available only for Mariner ADCPs using the Deck Box. If you are using a NMEA external device, see "Navigation Interface Considerations," page 39.

There are two ways to interface sensor data such as heading, pitch, and roll information with the ADCP data, either by analog signal input or by a serial ASCII input.

- Single- or multi-turn synchro heading outputs and single-turn synchro tilt sensor outputs for pitch and roll or
- Stepper heading outputs and single-turn synchro tilt sensor outputs for pitch and roll.
- Serial ASCII data input to the host computer running the TRDI ADCP software that conforms to one of the following NMEA standards.
- $_ _ HDT (NMEA 0183 standard of true heading only)
- $_ _ HDG (NMEA 0183 standard of magnetic heading only)
- $PRDID (TRDI proprietary NMEA string supporting heading, pitch, and roll)

The analog input is read by the Gyro Interface board in the Mariner Deck Box, and converted to a serial NMEA string to be used by the *VmDas* program at one of the COM ports. The advantage to these options is that gyro outputs can be used on vessels where flux-gate heading sensors and pendulums cannot. This is due to the effects from the hull on a flux gate compass and the accelerations of the ship on pendulum pitch and roll sensors. Table 5, page 32 lists the gyro interface options.

Use the RD-SIC-0 option when only stepper heading is available. Use the RD-SIC-1 option when either synchro or stepper heading is available. This option supports single-turn (1:1), multi-turn (36:1, 90:1, 360:1), and stepper voltage outputs from a ship's gyro or portable gyro. Use the RD-SIC-3 option with a gyro capable of resolving motion across the vertical plane (i.e., tilt synchro gyro). With the RD-SIC-3 option, you can use:

The Gyro Interface board uses up to three synchro-to-digital converter chips, a resistor network is used to configure the board for the input synchro stator voltages, and a DIP switch is used to configure the board for the turns ratio of a specific gyro. The Gyro Interface board supports a wide range of input synchro frequencies (50, 60, and 400 Hz).

We usually configure the Gyro Interface board at the factory to customer specifications for synchro stator voltage and gyro turns ratio. Table 6, page 32 lists the acceptable standard configurations. For us to configure the board you must provide us with either the Stepper

Sometimes, though, the customer chooses to use a gyro other than the one originally specified. Because of the need to change the gyro interface configuration "in the field," we provide technical information below.

Table 5: Gyro Interface Options by Model

Inputs allowed	Natel chips	Typical use
1 (RD-SIC-0)	0	Stepper heading only
1 (RD-SIC-1)	1	Synchro/Stepper heading only
3 (RD-SIC-3)	3	Synchro/Stepper heading, AND Synchro-only pitch and roll

Table 6: Acceptable Gyro Interface Configurations

Gyro Heading Input (Synchro)	
Frequency Input	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratios supported	Through a selectable DIP switch, the turns ratio can be 1:1, 36:1, 90:1, and 360:1
Gyro Heading Input (Stepper)	
Input Voltages	Most common ranges are from 35 to 70 VDC, with a positive or negative common. On special request, other voltages may be possible.
Stepper Ratio	Only a 6-step gyro can be used, where each step stands for 1/6 of a degree. See table below. ST0 ST1 ST2 DEGREE 1 1 0 (0/6) 0.000 1 0 0 (1/6) 0.167 1 0 1 (2/6) 0.333 0 0 1 (3/6) 0.500 0 1 1 (4/6) 0.667 0 1 0 (5/6) 0.833
Gyro Tilt Input (Synchro Only)	
Input Frequency	50Hz, 60Hz, or 400Hz
Stator Voltages	Through a variable scaling resistor package, the stator voltage can vary. Starting with a minimum voltage of 11.6 volts RMS, the most common voltages are 11.8, 26, 50, and 90 volts RMS.
Reference Voltages	20 to 150 VAC
Turns Ratio	1:1 only
Output Types (ASCII Only)	
Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
String Format	$PRDID,±PPP.PP, ±RRR.RR,HHH.HH (where P is for pitch, R is for roll, H is for heading. All are in decimal degrees.

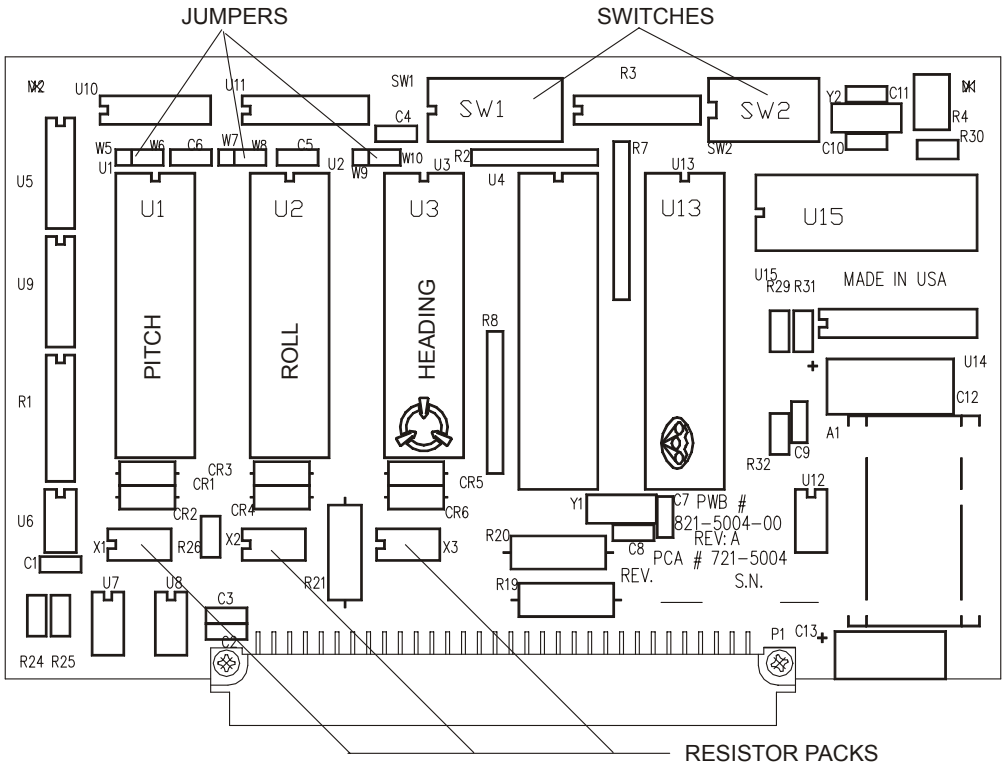

Figure 19. Gyro Interface Board

2.6.1 Determining the Synchro Stator Voltage

The best way to find the synchro stator voltage is to use the value listed in the gyro manual. If the manual does not list this value, you can determine the stator voltage by using an AC voltmeter and doing some calculations. After finding the stator voltage requirements, you will install one or more scaling-resistor packs on the Gyro Interface board. If you already know the stator voltage requirements, skip the rest of this section and go to "Determining the Size of the Scaling-Resistor Pack," page 34 to find the size of the scaling-resistor pack.

a. With the gyro synchro at a constant angle, measure the AC voltage across the following sets of leads. You must maintain this constant angle during your readings.

   1. S1 to S2:_____ VAC = S_{12}
   2. S2 to S3:_____ VAC = S_{23}
   3. S3 to S1:_____ VAC = S_{31}

b. Calculate the RMS stator voltage, V_S:

$$V_S = \left[\frac{S_{12}^2 + S_{23}^2 + S_{31}^2}{1.5} \right]^{1/2} = \textit{RMS stator voltage}$$

Usually, V_S will be a common stator voltage (11.8, 26.0, 50.0, or 90.0). If V_S is about equal to one of these values, you can probably assume your gyro is using a common value. If you are unsure of your readings, retake them at a different gyro angle and re-compute V_S. If you know your gyro is using an *uncommon* stator voltage value, you can still modify the scaling-resistor pack value for use with the Gyro Interface board (see "Determining the Size of the Scaling-Resistor Pack," page 34).

Verify the synchro stator voltages are within acceptable limits.

Each stator-pair voltage (S_{12}, S_{23}, and S_{31}) must be less than or equal to V_S.

All pairs of synchro stator voltages must be within the limits given below. For example, the check for one such pair is

$$0.7071 \leq \frac{(S_{12}^2 + S_{23}^2)^{1/2}}{V_S} \leq 1.2247$$

If these voltage checks are not within acceptable limits, then the synchro output is bad, the voltage measurements were incorrect, or the synchro angle was not constant during readings.

2.6.2 Determining the Size of the Scaling-Resistor Pack

As explained earlier, most synchros use one of the standard synchro stator voltages (V_S) listed in Table 7. The Gyro Interface board will work with any of these voltages by using the associated scaling-resistor pack to adjust the stator voltage input rating to 11.8 VAC.

Table 7: Standard Synchro Stator Voltages and Scaling Resistance

Common synchro stator reference voltages	Scaling resistance
11.8 VAC	0.0 kΩ (jumper)
26.0 VAC	39.2 kΩ, 1/8 W
50.0 VAC	100.0 kΩ, 1/8 W
90.0 VAC	221.0 kΩ, 1/8 W

If the gyro is using non-standard stator voltages, you can find the scaling resistance with the following equation.

$$R = (V_S - 11.8\ VAC) \times (2.76\ k\Omega)$$

The tolerance for this can be as large as 10%, but the four resistors in the scaling-resistor pack must be within 0.1% *of one another*. For example, the exact scaling-resistance value for a V_S of 50.0 VAC is 105.4 kΩ. However,

resistor values of 100 kΩ are more common. Because this value is within 10% of the calculated value, you can use four 100-kΩ resistors for the scaling-resistor pack if they are within 0.1% of one another.

CAUTION. If you configure the gyro interface board for a lower voltage than the actual synchro stator voltage, you could damage the board or the ADCP.

2.6.3 Installing the Scaling-Resistor Pack and W-Jumpers

After calculating the size of the scaling-resistor pack, you are ready to install the pack on the Gyro Interface board (Figure 19, page 33). Before you can install the scaling-resistor pack, you may have to change the resistors now in the pack. To do so, pull the resistor pack out of its socket on the Gyro Interface board, unsolder the old resistors, and install the new resistors. When the scaling-resistor pack has the correct resistors soldered in place, re-install the pack in its socket. Also, make sure the appropriate W-jumpers are installed. Table 8 lists the associated resistor sockets and W-jumpers.

Table 8: Natel Chip, Resistor Pack, and W-jumper Sockets

Function	Natel chip socket	Resistor pack socket	W-jumper socket
Pitch	U1	X1	W5
Roll	U2	X2	W7
Heading	U3	X3	W9

2.6.4 Determining and Setting the Synchro Turns Ratio

The best way to find the synchro turns ratio is to use the value listed in the gyro manual. If the manual does not list this value, you may have to experiment by trying the various settings on the Gyro Interface board. Table 9, page 36 lists the available turns ratios and their switch settings. To set the turns ratio, set the poles of switch S1 on the Gyro Interface board (Figure 19, page 33) to the appropriate position.

If you are guessing, try a 1:1 turns ratio first. The reason you want to use a 1:1 turns ratio is so you do not have to enter a heading bias (or initialization) value in any software program or adjustment on the front panel you are using. That is, whenever you use a *non-1:1 turns ratio* or a *stepper* voltage, it is possible for the Gyro Interface board to be out of alignment with the heading synchro. For example, if the ship's heading is 027° when you initialize the ADCP, the misalignment between the gyro and the Gyro Interface board will be 27°. When a misalignment condition occurs, you must account for the misalignment either by the front panel set Up/Down buttons, or in the software program you are using. You can use the EB-

command (Heading Bias) to align the Gyro Interface board to the gyro if you do not have the ability to initialize the WorkHorse ADCP through he front panel or in the software. Once set, the heading bias value is valid until you turn off the ADCP or gyro.

Table 9: Gyro Interface Switch 1 Settings

Turns ratio	P1	P2	P3	P4	P5	P6	P7	P8
1:1	C	O	C	O	O	C	C	C
36:1	C	O	C	O	O	O	C	C
90:1	C	O	C	O	O	C	O	C
360:1	C	O	C	O	O	O	O	C
Stepper enable	O	C	O	C	O	O	O	O

C = CLOSED O = OPEN

Table 10: Gyro Interface Switch 2 Settings

Pole	Setting	Function		
P1	C	Enables pitch and roll on the synchro board		
	O	Disabled pitch and roll on the synchro board		
P2-3	Baud rate	Baud rate	P2	P3
		2400	O	O
		4800	O	C
		9600	C	O
		19200	C	C
P4-5	Display rate	Display rate	P4	P5
		Continuous	O	O
		10 times per second	O	C
		2 times per second	C	O
		Once per second	C	C
P6	Not used			

2.6.5 Stepper Interface

If you are using a *stepper* voltage instead of a synchro voltage, remove the Synchro to Digital chip in socket U3 on the Gyro Interface board. Be sure to protect the Synchro to Digital chip from static discharge.

CAUTION. Synchro-to-Digital converter chips are **expensive**, so handle them with care.

Remember the following items when using the stepper interface

- Only a 6-step gyro can be used, where each step stands for 1/6 of a degree (see Table 6, page 32).
- If you are using roll and pitch inputs from a vertical gyro, the turns ratios for these inputs ***must*** be 1:1.
- Most common stepper voltage ranges are from 35 to 70 VDC, with a positive or negative common and this is what the gyro interface board is setup for from the factory. On special request, other voltages may be possible. The gyro Interface board uses resistors R19, R20, and R21 to set the current for the opto isolators on the stepper interface. Use Table 11 to determine the correct value of these resistors.

Table 11: Stepper Interface Resistor Values

Stepper Voltage	Resistor Value	Watt
35 to 70 VDC	8.2kΩ	1
20 to 35 VDC	4.0kΩ	1
70 to 110 VDC	16.0KΩ	2

2.6.6 Testing the Gyro Interface

You can use the front LCD display on the Deck Box to test the gyro interface. Turn on the Deck Box. If the LCD heading readout agrees with the gyro at several angles, you can assume the settings are correct. You also should have the gyro make a complete turn through 360°. Some lag may appear, but the LCD readout should change smoothly and in the same direction as the gyro.

If you do *not* have a 1:1 turns-ratio synchro input, and the LCD readout follows in the same direction but with a constant offset from the gyro value, you must use the initializing ↑, ↓, and SET buttons on the front of the deck box. If you do not have the initializing buttons, then you can set the offset in the *VmDas* Transforms page. If you are not using TRDI's *VmDas* program you can set the offset through the EB-command. This entry will align the two values when properly set; or one of two problems can exist.

- Incorrect turns-ratio value - If you are *not* sure of the turns ratio, try selecting the other turns-ratio values and retest the configuration.

CAUTION. Be sure to power down the Deck Box *before* changing the switch settings. You also should secure the gyro signals to the Deck Box, as these signals are still "live" at the Gyro Interface board terminals.

- Incorrect wiring hookup to gyro - If you *are* sure of the turns-ratio (i.e., found in gyro manual), the problem must be incorrect wiring. That is, the stator lines (S1, S2, S3) or reference lines (RH, RL) may be connected to the wrong gyro terminals. Use Table 12 or systematically swap pairs of stator or reference leads to correct wiring problems.

Table 12: Gyro Interface Troubleshooting Guide

"A" Gyro angle	"B" Angle displayed by heading readout (Shaded areas indicate reverse rotation)											
000	000	120	240	240	000	120	180	300	060	060	180	300
060	060	180	300	180	300	060	240	000	120	000	120	240
120	120	240	000	120	240	000	300	060	180	300	060	180
180	180	300	060	060	180	300	000	120	240	240	000	120
240	240	000	120	000	120	240	060	180	300	180	300	060
300	300	060	180	300	060	180	120	240	000	120	240	000
Gyro conn.	"C" Possible ADCP Connector Configurations											
	1	2	3	4	5	6	7	8	9	10	11	12
RH	RH	RH	RH	RH	RH	RH	RL	RL	RL	RL	RL	RL
RL	RL	RL	RL	RL	RL	RL	RH	RH	RH	RH	RH	RH
S1	S1	S2	S3	S2	S3	S1	S1	S2	S3	S2	S3	S1
S2	S2	S3	S1	S1	S2	S3	S2	S3	S1	S1	S2	S3
S3	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2

NOTE

1. With a gyro angle of "a," the heading readout will show an angle of "b" if the gyro interface cable wires are connected as shown in "c." For example - if the gyro is at an angle of 120° ("a"), and the heading readout is showing a value of 300° ("b"), the interface is wired in either configuration #7 or #10 ("c"). If the heading readings rotate in the same direction as the gyro, the interface is wired as #7; if the rotation is in the reverse direction, the interface is wired as #10.
2. As shown above, only configuration #1 in "c" is correct for gyro interface wiring.
3. Configurations 7-12 occurs when reference wires RH and RL are reversed, producing errors of 180°.
4. Configurations 2, 3, 8, and 9 occur when the S1-S2-S3 wires are rotated, producing errors of 120°.
5. Switching any two of the S1-S2-S3 wires, as in configurations 4, 5, 6, 10, 11, and 12 (shaded in table), cause synchro rotation to be reversed and result in errors of varying degrees.
6. Setting the gyro to 000° will produce an offset that is a multiple of 60° for all possible wiring configurations.
7. Leaving any of the S1-S2-S3 connections "open" will give unpredictable results.

2.7 Navigation Interface Considerations

VmDas can read in, decode, and record ensembles from an ADCP and NMEA data from some specific (i.e. GPS and attitude sensors) external devices. *VmDas* stores this data in both raw data files (leaving all original data input in its original format) and in a combined, averaged data file. *VmDas* uses all of this data to create different displays for the user.

VmDas looks for, and utilizes the following strings if transmitted: standard GGA (position), HDG/HDT (Heading), VTG (speed and track) messages, and a proprietary PRDID (pitch and roll) message.

As well as being able to input NMEA strings to *VmDas*, it can produce NMEA output strings of speed log information. The speed log contains VDVBW (ground/water speed) and VDDBT (depth).

NOTE. For more information about NMEA data, see the *VmDas* and *WinRiver* User's Guides.

2.8 Power Considerations

Use the following sections to determine the power requirements for your ADCP system. All Workhorse tests and operations work equally well using any of the listed power sources.

2.8.1 Monitor/Sentinel Power Considerations

WorkHorse Monitor and Sentinel ADCPs require +20 to 50 VDC to operate. The standard AC Adapter runs on any standard AC power and supplies +48 VDC to run the Workhorse when the batteries are not connected. The Sentinel's internal battery supplies +42 VDC.

NOTE. The AC Adapter input voltage is sufficient to override the internal battery voltage (i.e. the ADCP will draw all power from the AC adapter even if the battery is installed and connected).

Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

NOTE. The transmitted power is decreased 1 DB if the input voltage drops from 42 VDC to 33 VDC. For a 300kHz WorkHorse ADCP, each DB will result in a decrease in range of one default depth cell.

Power on Cycle

The power supply must be able to handle the inrush current as well. Inrush current is the current required to fully charge up the capacitors when power is applied to the ADCP. The capacitors provide a store of energy for use during transmit. The inrush current is as high as 3 Amps rms. The ADCP will draw this amperage until its capacitors are fully charged.

If the power supply limits the current or the power drop on the cable is significant, then the power on cycle will take longer. It can take up to one minute. You do not want the power to shut down during the inrush current draw, as this may not allow the ADCP electronics to start.

AC Power Supply

The AC power supplies provided by TRDI with the system are designed to maintain a 400-ma supply under this load. They are 75-Watt supplies, with 48 VDC, 1.5 amp outputs. They will not fall back to 0 amps, 0 volts under a load. Customer provided power supplies might shut themselves down under such a load; when that occurs, the ADCP will not wakeup.

2.8.2 Mariner Power Considerations

The Mariner deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 98-264 VAC, 50-60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200-kHz ADCP.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

NOTE. Transmitted power increases or decreases depending on the input voltage. Higher voltage to the ADCP (within the voltage range of 20 to 50 VDC) will increase the transmitted power. The transmitted power is increased 6 DB if you double the input voltage from 24 VDC to 48 VDC. For a 300kHz WorkHorse ADCP, each additional DB will result in an increase in range of one default depth cell.

ADCP Internal Batteries. If you want the ADCP to use internal battery power (Sentinel Workhorse ADCP or external battery pack) rather then the deck box power, do the following.

a. Turn OFF or disconnect all power to all ADCP system equipment.

b. Remove the screws on the top cover of the deck box. Lift the cover off.

c. Locate the Filter Interface board (see the Mariner User's Guide for a drawing of the deck box board locations). Locate connector J18 and disconnect the twisted black and white cable plugged into this connector. The power from the deck box to the ADCP has now been disabled. Only the batteries are powering the ADCP.

2.9 Installation Procedures (Overview)

Read these steps before doing them. In general, follow them in the order listed. Some may differ for your installation, so modify them as necessary. Some can be done simultaneously (e.g., hardware installation and software loading). If you have problems or questions, call us.

NOTE. The following procedure applies to WorkHorse Mariner ADCPs. Some parts may apply to WorkHorse Monitor/Sentinel ADCPs if they are being mounted to a vessel.

a. On receipt of the system, read the WorkHorse Technical Manual.

b. Before installing the system, test the transducer and deck box right out of the shipping container. Do the following.

   1. All power to the system DISCONNECTED.
   2. Review "Power Considerations," page 40.
   3. Connect the I/O cable from the deck box to the ADCP.
   4. Connect the serial I/O cable from the computer to the deck box.
   5. Connect the power cable to the deck box and apply power to the system (the ADCP User's Guide shows all cable connections).
   6. Follow testing procedures in "Maintenance," page 45. Test the system. If errors occur, use "Troubleshooting," page 116.

c. Prepare the system for shipboard installation. Disconnect all power to the system. Disconnect all interface cables.

d. Review "Transducer Head Mounting Considerations," page 18. Install the transducer head. Mechanically align the system (see "Alignment Procedures (Overview)," page 43).

CAUTION. Take steps to prevent leaks through the hull and gate valves.

e. Review section "Mariner Deck Box Mounting Considerations," page 28. As necessary, do the following.

   1. Install the Synchro Interface board in the chassis (see the Mariner's User Guide).
   2. Check all switch settings on the gyro board (shown in the Mariner's User Guide).
   3. Install the deck box.

f. Review "Computer Considerations," page 30. Install the computer.

g. Review "Cabling Considerations," page 29. As necessary, route and connect the following cables:

- Transducer to deck box (J17) interface cable.
- Gyro to deck box (J22) cable.

CAUTION. Signals may be present.

- Navigation to computer cable.

CAUTION. Signals may be present.

h. As necessary, load the software on the computer's hard drive. See the Software User's Guide and the Help files for each program.

i. Configure *VmDas* or *WinRiver*. See the software's help file and the *VmDas* or *WinRiver* User's Guide for help on configuring the program.

j. Do the Dock Side Tests (see "Dock Side Tests," page 102). If errors occur, use "Troubleshooting," page 116.

k. Do the Sea Acceptance testing (see "Sea Acceptance Tests," page 105). The Sea Acceptance tests include the following checks.

- Interference
- Water Profile Range
- Ringing and (cross-coupling, other pingers, noise)
- Water Profile Reasonableness (transducer alignment)
- Bottom-track (range, accuracy)

2.10 Alignment Procedures (Overview)

NOTE. This section does not apply to stationary systems (such as bottom mounted Sentinels). These systems use an internal compass by default.

The mechanical alignment of the transducer head is important to ADCP data accuracy. Mechanically mount the head as close as possible to your reference point. This is usually with the Beam 3 mark at 0° or 45° relative to the ship's fore-to-aft centerline. You also must mount the transducer head as level as possible using the ship's roll and pitch references. Review the "Transducer Head Mounting Considerations," page 18 for alignment considerations.

VmDas uses the **Heading Correction Parameters** on the **Transforms** tab to align the ADCP's north reference (Beam 3 mark) to the north reference of an external gyro/compass. Ships use the bow as the north reference.

When the WorkHorse is aboard a vessel, the mechanical alignment of the transducer head (Beam 3 mark) is usually aligned with the ship's fore-to-aft centerline (0°) or rotated 45° clockwise. To conceptually determine the

misalignment angle, visually hold the ADCP still and turn the ship gyro's north reference to match the ADCP's north reference. For example, if the Beam 3 mark is pointing at the bow (Figure 20), the misalignment angle is zero. If the Beam 3 mark is pointing 45° to starboard (Figure 20), you must turn the ship a +45° to align the two north reference points. Conversely, if the Beam 3 mark is pointing 45° to port, you must turn the ship a -45° to align the two reference points.

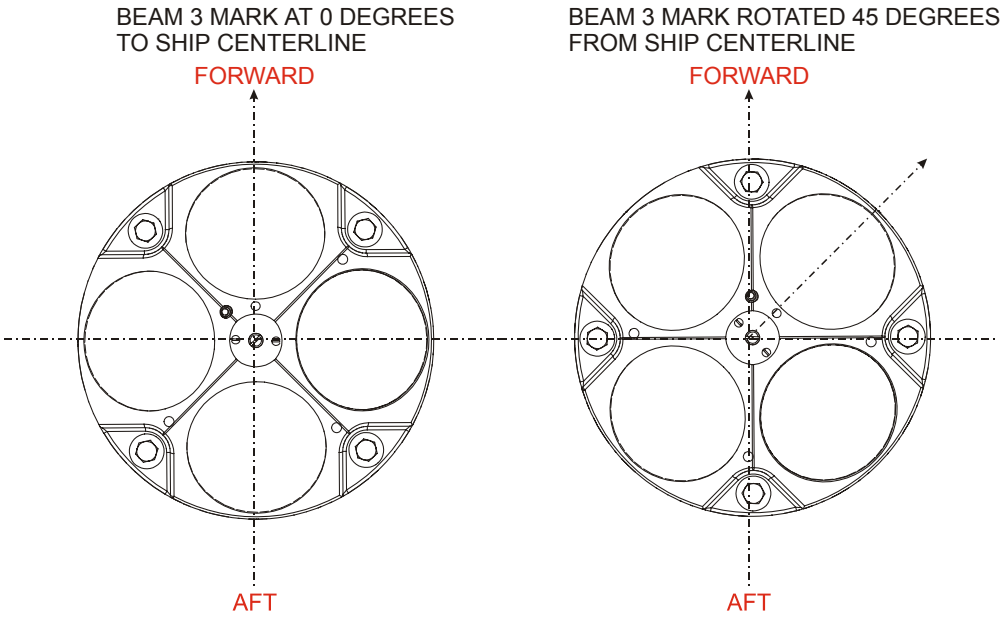

Figure 20. Transducer Misalignment Reference Points

NOTE. The alignment of the transducer installation holes on the Mariner Adapter Plate to the centerline of the transducer is within 0.15 degrees. We recommend you choose a bolt (or stud) that fills the installation holes as close as possible to limit any additional misalignment.

3 Maintenance

This section explains how to prepare the WorkHorse for deployment, how to do certain maintenance procedures, and how to prepare the WorkHorse for storage or shipment.

Table 13, page 76 lists the items in the tools and spares parts kit. Use this kit when doing routine WorkHorse maintenance.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice will be posted to our web site on the Customer Care page (www.rdinstruments.com). Please check our web site often.

3.1 I/O Cable and Dummy Plug

The underwater connector (on the end-cap) and the I/O cable and dummy plug are molded wet-mate-able connectors. The end-cap connector is a factory-installed item. We do not recommend removing it for any routine maintenance.

NOTE. The dummy plug should be installed any time the I/O cable is removed. Use the dummy plug when the WorkHorse is in storage or is being handled.

3.1.1 Disconnecting the I/O Cable or Dummy Plug

The cable should be disconnected with a straight outward motion only. Use the following procedure to disconnect the cable.

CAUTION. When disconnecting the WorkHorse I/O cable, do not apply any upward force on the connector as it is being pulled off. Applying an upward angle as the cable is disconnected puts stress on the end-cap connector. This may cause several serious problems: a) The end-cap connector or connector pins can crack. b) The O-ring on the bottom of the end-cap connector can be damaged. c) The molded urethane on the end-cap connector may separate from the brass insert. **If the end-cap connector is damaged in any of these ways, your ADCP will flood.**

a. Release the retaining strap by pulling it over the connector.

b. Grasp the cable close to the end-cap (see Figure 21, page 46). Your thumb should rest against the edge of the end-cap.

c. Pull the cable straight out away from the end-cap with a gentle side-to-side rocking motion. Do not apply any upward force on the connector as it is being disconnected.

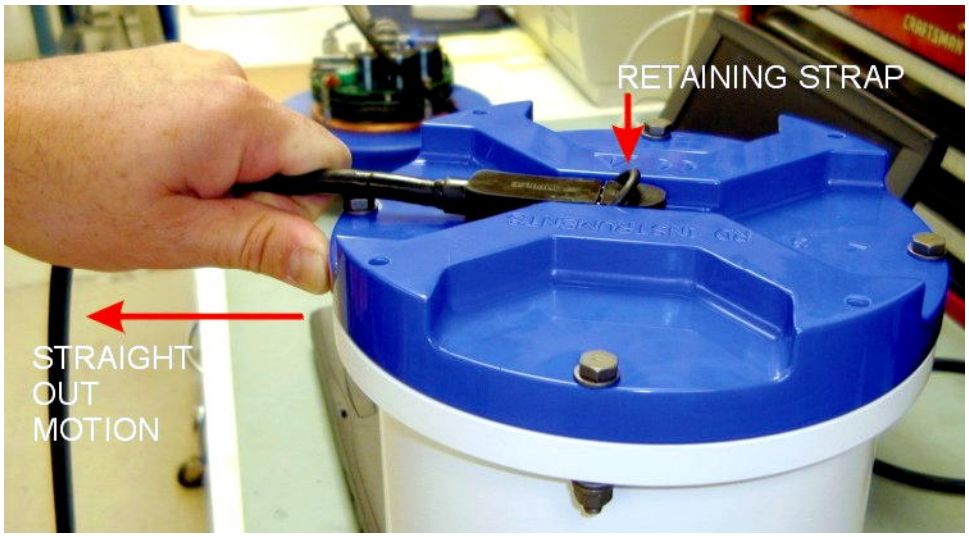

Figure 21. Removing the I/O Cable

3.1.2 Connecting the I/O Cable or Dummy Plug

The cable should be connected with a straight inward motion only. Use the following procedure to connect the cable.

> **CAUTION.** When connecting the WorkHorse I/O cable, do not apply any upward force on the connector as it is being pushed on. Applying an upward angle as the cable is connected puts stress on the end-cap connector. This may cause several serious problems: a) The end-cap connector or connector pins can crack. b) The O-ring on the bottom of the end-cap connector can be damaged. c) The molded urethane on the end-cap connector may separate from the brass insert. **If the end-cap connector is damaged in any of these ways, your ADCP will flood.**

a. Apply a light coat of DC-111 lubricant to the rubber portion of the end-cap connector pins. This will help seat the connector.

b. Gently push the cable straight in toward the end-cap connector. Do not apply any upward force on the connector as it is being connected.

c. Roll the retaining strap over the connector.

3.2 WorkHorse Disassembly

This section explains how to remove and replace the end-cap or transducer head to gain access to the ADCP's electronics, batteries, and internal recorder. Read all instructions before doing the required actions.

3.2.1 End-Cap Removal Procedures

To remove the end-cap, do the following steps. Use "Parts Location Drawings," page 77 for parts identification.

NOTE. When you need access to the electronics, TRDI recommends removing the transducer head assembly (see "Transducer Head Assembly Removal," page 48).

a. Dry the outside of the Workhorse.

b. Stand the Workhorse on its transducer face on a soft pad.

c. Remove all power to the Workhorse.

d. Remove the I/O cable and place the dummy plug on the I/O cable connector (see "I/O Cable and Dummy Plug," page 45).

CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

a. Loosen (do not remove) the four end-cap bolts to vent the system.

b. Once all four end-cap bolts (6-mm) have been loosened, remove the bolts from the end-cap.

NOTE. Make sure you save all hardware removed during this procedure for re-assembly.

e. Carefully pull the end-cap away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.

f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.

g. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see "O-ring Inspection and Replacement," page 49). Even small scratches can cause leakage around the O-ring seal.

3.2.2 Transducer Head Assembly Removal

> **NOTE.** When you need access to the Sentinel internal battery, remove the end-cap assembly (see "End-Cap Removal Procedures," page 47).

a. Remove all power to the Workhorse.

b. Remove the I/O cable and place the dummy plug on the I/O cable connector (see "I/O Cable and Dummy Plug," page 45).

c. Stand the Workhorse on its end-cap.

> **CAUTION.** If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

a. Loosen (do not remove) the four titanium bolts (8-mm) bolts to vent the system.

b. Once all four bolts have been loosened, remove the four bolts that attach the housing flange to the transducer head assembly.

d. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.

> **NOTE.** The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

e. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.

f. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage (see "O-ring Inspection and Replacement," page 49).

g. When you are ready to re-assemble the workhorse, see "Workhorse Re-assembly," page 48.

3.3 Workhorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use "Parts Location Drawings," page 77 for parts identification.

a. If you are sealing the Workhorse for a deployment, be sure you have done all appropriate maintenance items (see "Sealing the Workhorse for a Deployment," page 68).

b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.

c. Install two fresh bags of desiccant just before closing the Workhorse (see "Desiccant Bags," page 67).

3.3.1 O-ring Inspection and Replacement

This section explains how to inspect/replace the Workhorse O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See "Parts Location Drawings," page 77 for the locations of the following O-rings. Read all instructions before doing the required actions.

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

We strongly recommend replacing these O-rings whenever you disassemble the Workhorse. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less then 0.1 mm (0.004 in.).

CAUTION. If the O-ring appears compressed from prior use, replace it. **Weak or damaged O-rings will cause the ADCP to flood.**

b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may need repair.

CAUTION. Check the O-ring groove thoroughly. **Any foreign matter in the O-ring groove will cause the ADCP to flood.**

c. If a scratch is on the plastic housing flange O-ring groove, it may be gently sanded using 600-grit (wet) sandpaper. Use care not to cause further damage.

d. Lubricate the O-ring with a thin coat of DC-111 lubricant (Table 13, page 76, item 5). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

3.3.2 End-cap Replacement

a. Stand the Workhorse on its transducer face on a soft pad.

b. Inspect, clean, and lubricate the O-ring on the housing (see "O-ring Inspection and Replacement," page 49). Apply a very thin coat of silicone lube on the O-ring.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

c. Connect the internal I/O connector to the plug on the common mode choke.

d. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face O-ring remains in its retaining groove.

CAUTION. Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

e. Examine the titanium end-cap assembly nuts, bolts, and washers (6-mm) for corrosion; replace if necessary. The "Parts Location Drawings," page 77 shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Workhorse properly.

f. Install all four sets of hardware until "finger-tight."

g. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress

the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).

CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more then the others, the O-ring can become pinched or torn. **A damaged O-ring will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

3.3.3 Transducer Head Assembly Replacement

a. Stand the Workhorse on its end-cap.

b. Inspect, clean, and lubricate the O-ring on the housing (see "O-ring Inspection and Replacement," page 49). Apply a very thin coat of silicone lube on the O-ring.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

c. Connect the internal I/O connector to the plug on the common mode choke.

d. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-ring. Make sure the face O-ring remains in the retaining groove.

CAUTION. Check that no wires or any other object is pinched between the transducer head assembly and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

e. Examine the titanium transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The "Parts Location Drawings," page 77 shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Workhorse properly.

f. Install all four sets of hardware until "finger tight."

g. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.

CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more then the others, the O-ring can become pinched or torn. **A damaged O-ring will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

3.4 Mariner Adapter Plate

The adapter plate helps mount the Mariner transducer head to a vessel. See the "Outline Installation Drawings," page 157 for dimensions. The following procedure explains how to install and remove the Adapter Plate on a Workhorse Mariner ADCP.

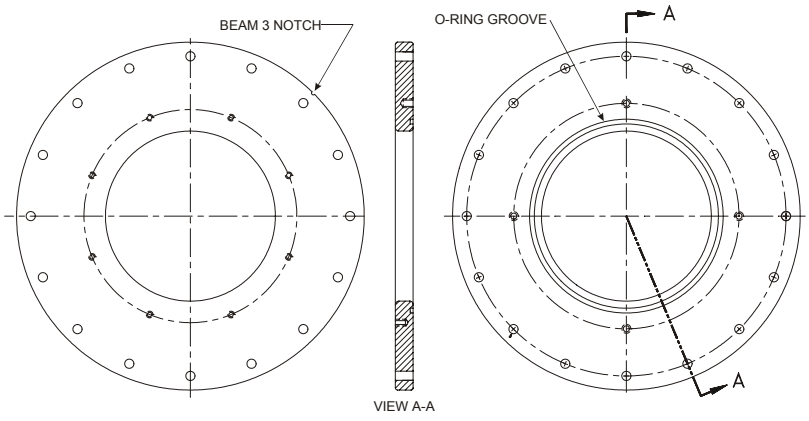

Figure 22. Mariner Adapter Plate

3.4.1 Installing the Adapter Plate

a. Remove the Transducer Assembly (see "Transducer Head Assembly Removal," page 48).

b. Inspect and clean the O-ring groove of the Housing Assembly.

c. Inspect, clean, and lubricate the O-ring (2-260) on the Housing Assembly where the Transducer Assembly was just mounted. Apply a very thin coat of silicone lube on the O-ring.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

d. Inspect and clean the Adapter Plate. Be sure no scratches, dents, or foreign matter is around the area that will be contact with the O-ring on the Housing Assembly.

e. Place the adapter plate on the Housing Assembly, ensuring that the O-ring is not pinched or damaged. Rotate the plate such that the alignment notch in the plate is in alignment with the beam 3 arrow on the end cap.

CAUTION. Check that no wires or any other object is pinched between the adapter plate and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

f. Using four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Adapter Plate to the Housing Assembly. Install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.

g. Install all four sets of hardware until "finger-tight."

h. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).

CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more then the others, the O-ring can become pinched or torn. **A Damaged O-ring will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing flange. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the transducer 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

i. Install a new desiccant bag from the Adapter Plate Kit into the Housing Assembly.

j. Inspect and clean the O-ring groove of the Adapter Plate.

k. Inspect, clean, and lubricate the O-ring (2-260) from the Adapter Plate Kit and set this O-ring into the groove on the Adapter Plate.

l. Connect the cable from the end cap assembly to the Power I/O board on the Transducer Assembly.

m. Place the Transducer Assembly onto the Adapter Plate, ensuring that the O-ring is not pinched or damaged. Rotate the Transducer Assembly such that the beam-3 mark is aligned with both the alignment notch in the Adapter Plate and the beam-3 arrow on the end cap.

CAUTION. Check that no wires or any other object is pinched between the transducer head assembly and the adapter plate. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

n. Using the remaining four of the titanium 8-mm bolts supplied in the Adapter Plate Kit, secure the Transducer Assembly to the Housing Assembly. You should install the split lock washer next to the head of the bolt followed by a flat washer before installing the 8-mm bolts.

o. Install all four sets of hardware until “finger-tight.”

p. Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches).

CAUTION. Apply equal pressure to the O-ring as you tighten the bolts. If one bolt is tightened more then the others, the O-ring can become pinched or torn. **A Damaged O-ring will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic housing flange. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the transducer 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

3.4.2 Removing the Adapter Plate

a. Remove the Transducer Assembly (see "Transducer Head Assembly Removal," page 48).

b. Remove the four titanium 8-mm bolts that secure the Adapter Plate to the Housing Assembly.

c. Separate the Adapter Plate from the Housing Assembly.

d. Install the Transducer Assembly (see "Transducer Head Assembly Replacement," page 51).

3.5 Sentinel Battery Packs

The Sentinel system uses battery packs to provide power. Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions).

NOTE. Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries, and can easily be replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended ADCP deployments.

NOTE. WorkHorse Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal the ADCP before deployment.**

3.5.1 Sentinel Battery Replacement

To replace the battery pack, do the following steps.

a. Remove the end-cap (see "End-Cap Removal Procedures," page 47).

b. Disconnect the battery cable going to the common mode choke.

c. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (Figure 34, page 79).

d. Remove the support plate.

e. Slide out the used battery pack.

f. Slide a new battery pack onto the four posts. Make sure the I/O cable is not pinched by the battery pack.

g. Use the large rubber bands (supplied with each new pack) to hold the cables in place.

h. Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.

CAUTION. Older WorkHorse Battery Packs may not contain permanent internal sleeves that protect the battery pack from any accidental shorting against the four End Cap studs. If the battery pack shorts out, it will blow a protective fuse inside the battery pack. **The battery pack is then open and will read as zero volts DC.**

i. Position the support plate over the four posts.

j. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the wing nuts firmly to hold the battery in place.

k. Place a battery pack rubber band (two spare rubber bands are provided with each new battery) around all four wing nuts. This will prevent the wing nuts from backing off the post.

CAUTION. The Workhorse Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. **This has caused the PIO board to short out.**

l. Connect the battery cable going to the common mode choke (see Figure 36, page 81)

m. Install the end-cap (see "End-cap Replacement," page 50).

n. Align the compass (see "Compass Calibration," page 58).

3.5.2 External Battery Case Battery Replacement

The external battery case holds two battery packs to provide power. Batteries should be replaced when the voltage falls below +30 VDC (measured across the battery connector under no-load conditions). To replace the battery packs, do the following steps.

CAUTION. The external battery case should not be connected or disconnected underwater. The electrical output power will degrade the connector contacts and present a **potential electrical shock hazard to installation personnel** when the power connector is short-circuited in water. The external battery case output power cannot be enabled or disabled underwater.

a. Remove one end-cap from the external battery pack (see Figure 35, page 80).

b. Place the external battery case on its side and carefully pull out the battery pack (attached to the end-cap).

c. Disconnect the battery power cable from the wiring harness.

d. Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts (see Figure 34, page 79).

e. Remove the support plate.

f. Slide out the used battery pack.

g. Slide a new battery pack onto the four posts. Make sure the wiring harness is not pinched by the battery pack. Use the large rubber bands (supplied with each new pack) to hold the cables in place.

h. Position the support plate over the four posts.

i. Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the nuts to hold the battery in place.

j. Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.

CAUTION. Older WorkHorse Battery Packs may not contain permanent internal sleeves that protect the battery pack from any accidental shorting against the four End Cap studs. If the battery pack shorts out, it will blow a protective fuse inside the battery pack. **The battery pack is then open and will read as zero volts DC.**

k. Connect the battery power cable to the wiring harness.

l. Install the end-cap/battery pack assembly (see "End-cap Replacement," page 50).

m. Repeat steps "a" through "l" to replace the other battery pack.

n. Replace the desiccant bags on each battery just before sealing the external battery case (see "Desiccant Bags," page 67).

3.6 Compass Calibration

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement. You should be aware of the following items:

- We recommend against calibrating the Workhorse while on a ship. The ship's motion and magnetic fields from the hull and engine will likely prevent successful calibration.
- If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the Workhorse inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.

NOTE. If only the battery modules were removed and replaced back in the same orientation, the compass does not require calibration. If the battery cores were replaced, you **must** verify the compass.

Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an external battery pack. The external battery housing holds two batteries, and can easily be replaced on-site. If properly used, no compass calibration will be required. The external battery pack provides an option for extended ADCP deployments.

3.6.1 Preparing for Calibration

a. Place the Workhorse on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the Workhorse on the floor as far away from metal objects as possible. Use the cardboard to rotate the Workhorse during calibration—this way you will not scratch the Workhorse. Place the ADCP in the same orientation as it will be deployed.

NOTE. If you will deploy your Workhorse looking up, calibrate it looking up. If you will deploy it looking down, calibrate it looking down.

CAUTION. If you calibrate the compass in one direction (up or down) and deploy the ADCP in the opposite direction (i.e. calibrate it in a downward position and deploy it in a upward position) the compass calibration will be invalid. Compass errors in excess of 5 degrees may occur.

b. Connect the Workhorse as shown in the appropriate ADCP User's Guide.

c. Start *BBTalk*. See the RDI Tools User's Guide for assistance on using *BBTalk*.

3.6.2 Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the Workhorse computes and displays the results.

NOTE. Verify the compass if you have just replaced the memory module, or any ferrous metals is relocated inside or around the Workhorse housing. Calibrate the compass if the batteries have been replaced (see "Compass Calibration Procedure," page 60).

a. Prepare the ADCP for calibration (see "Preparing for Calibration," page 58).

b. Using *BBTalk,* send a Break to wake up the Workhorse.

c. At the > prompt, type **AX** and press the **Return** key.

d. When prompted, rotate the Workhorse slowly 360 degrees (approximately 5 degrees per second). Pay particular attention to the Overall Error. For example;

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5():   ( 1.55(
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                  ( 1.54(
      Double Cycle Error:                                  ( 0.07(
      Largest Double plus Single Cycle Error:              ( 1.61(
      RMS of 3rd Order and Higher + Random Error:          ( 0.31(
```

If the overall error is less than 2°, the compass does not require alignment. You can align the compass to reduce the overall error even more (if desired).

3.6.3 Compass Calibration Procedure

The built-in automated compass calibration procedure is similar to the alignment verification, but requires three rotations instead of one. The Workhorse uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the Workhorse for the two calibration rotations, the Workhorse checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the ADCP. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

a. Prepare the ADCP for calibration (see "Preparing for Calibration," page 58).

b. Using *BBTalk,* send a Break to wake up the ADCP.

c. At the > prompt, type **AR** and press the **Return** key. This will return the compass to the factory calibration matrix.

d. At the > prompt, type **AF** and press the **Return** key. Choose option "b" to start the calibration procedure.

e. Tilt the ADCP (see Figure 23, page 61). Tilt an upward-looking Workhorse with a block under one side of the end-cap. A 35-mm block will give you an 11-degree tilt. Check the on-screen instructions to see if the orientation is OK. Adjust as necessary.

NOTE. The tilts must remain constant during the rotations. The transducer beam is the center point of the rotation.

f. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).

g. The second rotation requires the ADCP to be tilted 15 degrees in another direction than from the first rotation (see Figure 23, page 61). Follow the on-screen instructions to orient the ADCP correctly. When prompted, rotate the ADCP slowly 360 degrees (approximately 5 degrees per second).

h. The third rotation requires the ADCP to be tilted 15 degrees in another direction than from the first and second rotations. Follow the on-screen instructions to orient the ADCP correctly.

i. If the calibration procedure is successful, it records the new calibration matrix to nonvolatile memory. The ADCP will not change its matrix unless the calibration is properly carried out.

j. If the calibration procedure is not successful, return your ADCP to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

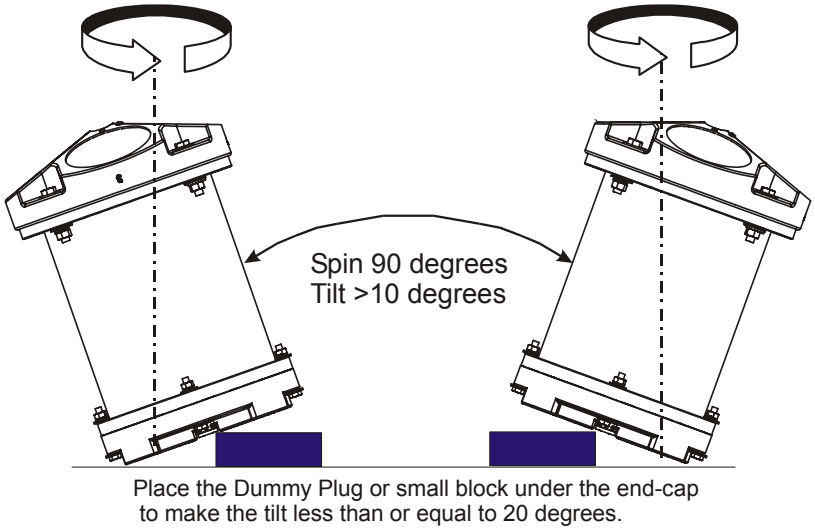

Figure 23. Compass Calibration

3.7 Fuse Replacement

PIO Board. There is one fuse on the PIO Board (see Figure 36, page 81) that protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your input power before applying power again.

a. Turn off the power.

b. Remove the transducer head (see "Transducer Head Assembly Removal," page 48).

c. The PIO board fuse is located next to the internal I/O connector. Use a small flat-blade screwdriver to open the fuse housing. Turn the end 180° (counter-clockwise) to open the fuse housing.

d. Gently pull the fuse housing out. Turn the housing to remove the fuse.

e. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 13, page 76 item 7).

f. Install the transducer head (see "Transducer Head Assembly Replacement," page 51).

g. Test the system (see "Testing the WorkHorse," page 95).

External Battery Pack. One fuse in the external battery pack protects the Workhorse from excessive incoming power. If this fuse continues to blow, check your battery packs before connecting the external battery case again.

a. Remove one end-cap from the external battery pack (see "End-Cap Removal Procedures," page 47).

b. Carefully lift out the battery pack (attached to the end-cap).

c. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse (Table 13, page 76 item 7).

d. Install the end-cap (see "End-cap Replacement," page 50).

e. Measure the voltage output of the external battery case across pin 3 (+) and pin 7 (-) on the external connector. If both battery packs are fresh, you should measure approximately +42 VDC.

Mariner Deck Box. The Deck Box back panel has three fuses.

- FUSE F1 - 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J25 (20-60 VDC power input).
- FUSE F2 - 10 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J26 (12 VDC power input).

- FUSE F3 - 5 Amp, 250 V, slow-blow, 5x20mm, clip-mounted. This fuse protects Deck Box circuits from input overload on J27 (98 - 264 VAC power input).

a. Turn off power to the deck box.

b. Press down gently on the top edge of the fuse holder.

c. Pull the fuse holder out and down. It will extend approximately one inch. Do not attempt to remove it completely.

d. The fuse closest to the inside of the deck box is the fuse in use. Check the fuse using an ohmmeter. There may be a spare fuse attached to the holder. Verify that the spare fuse is the correct voltage and amperage before using.

e. Place the replacement fuse (and another spare as necessary) in the fuse holder.

f. Gently push the fuse holder back in place.

g. Turn on power and test the system (see "Testing the WorkHorse," page 95).

Mariner Deck Box Power Supply. The Deck Box Power Supply has one fuse (F1 - 5 Amp, 250 V, fast-blow, clip-mounted). This fuse protects the Deck Box Power Supply circuits from input overload.

a. Turn off power to the deck box.

b. Remove the Deck Box top cover.

c. Remove the fuse from the clips. Check the fuse using an ohmmeter. Replace the fuse if necessary with the correct voltage and amperage fuse.

d. Replace the Deck Box top cover.

e. Turn on power and test the system (see "Testing the WorkHorse," page 95).

3.8 Communications Setting

A switch on the PIO board (see Figure 24) changes the communication settings between RS-232 and RS-422. Your computer and the Workhorse must both be set to the same communication setting. Use the RS-232-to-RS-422 converter if the Workhorse is using RS-422 communications and you computer only has an RS-232 COM port.

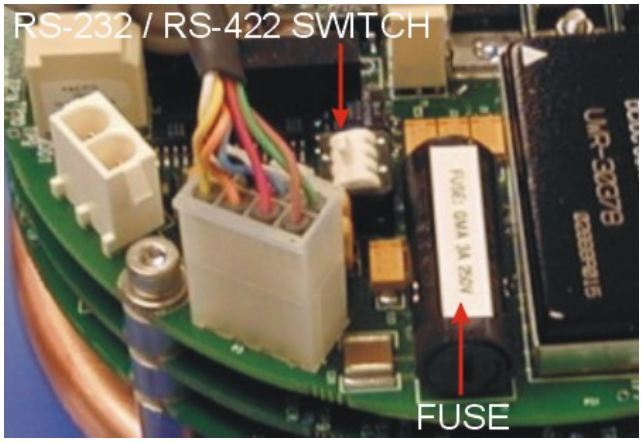

Figure 24. Communication Switch and Fuse

3.9 Firmware Upgrades

The firmware for Workhorse ADCPs in located on flash RAM chips on the CPU board. Firmware must be downloaded. Use the following procedure to download firmware to the Workhorse.

a. Connect your ADCP to the computer as shown in the appropriate ADCP User's Guide.

b. Start the program *WHxxFW.exe* (where *xx* is the firmware number).

c. Click **Setup**. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of the firmware.

d. Click **Next** and follow the on-screen prompts.

e. If you are not able to install the new firmware, contact Customer Service.

f. After successfully upgrading the firmware, use *BBTalk* to test the ADCP (see "Testing the WorkHorse," page 95).

3.10 Feature Upgrades

The feature upgrade installation program is used to install Bottom Tracking, Shallow Water Bottom Mode, Lowered ADCP (LADCP), Water Profiling (for Navigators), High-Resolution Water-Profiling mode, High Ping Rate, and Waves capabilities in a Workhorse ADCP.

NOTE. The upgrade disk is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.

NOTE. Many feature upgrades require the latest firmware version to be installed in your ADCP. If you need to update the firmware, do this before installing the feature upgrade (see "Firmware Upgrades," page 64).

a. Set up the Workhorse as shown in the appropriate ADCP User's Guide.

b. Place the feature upgrade disk in the disk drive (usually the "A" drive).

c. Click the Windows **Start** button, and then select **Run**.

d. In the **Open** box, type A:*xxx*.exe, where *xxx* is the ADCP's CPU serial number. The installation program will start (see Figure 25). The program is encoded with the ADCP's serial number and the requested feature upgrade.

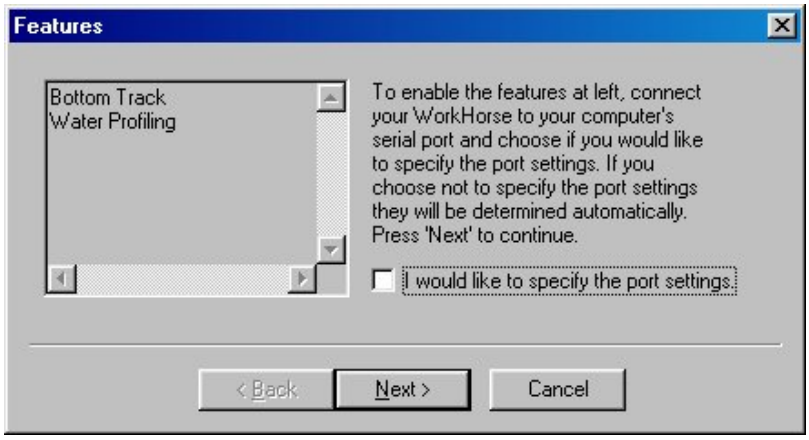

Figure 25. Installing Feature Upgrades

e. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.

f. Select the **Serial Port** and **Baud Rate**.

g. Click **Next** to install the feature upgrade. Click the **Finish** button to exit the program.

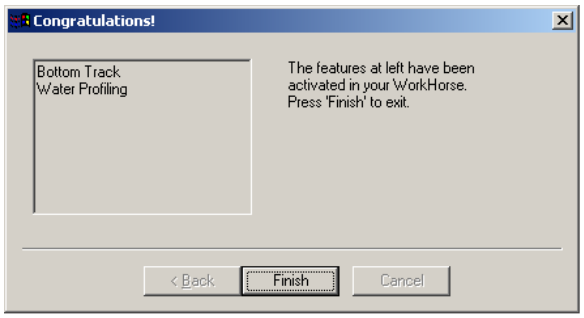

Figure 26. Feature Upgrade Completed

h. Start *BBTalk* and use the OL command (see the Workhorse Commands and Output Data Format guide) to verify the feature upgrade has been installed.

3.11 PC Card Recorder

The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Workhorse's electronics (see Figure 27). To recover data, the card can be removed and used in a personal computer (PC), or left in the Workhorse, and accessed by using *WinSC* (see the *WinSC* User's Guide). To remove or install a PC card, do the following.

a. Turn off power to the Workhorse.

b. Remove the transducer head (see "Transducer Head Assembly Removal," page 48).

c. Remove the PC cards by pushing the button on the side of the PCMCIA card slot. The card should "pop" out of the connector. If you cannot reach the release button with your finger, use a plastic pen or non-conductive tool to depress the button. Do not try to force the card in or out of the connector. PC cards slide easily in or out when properly oriented.

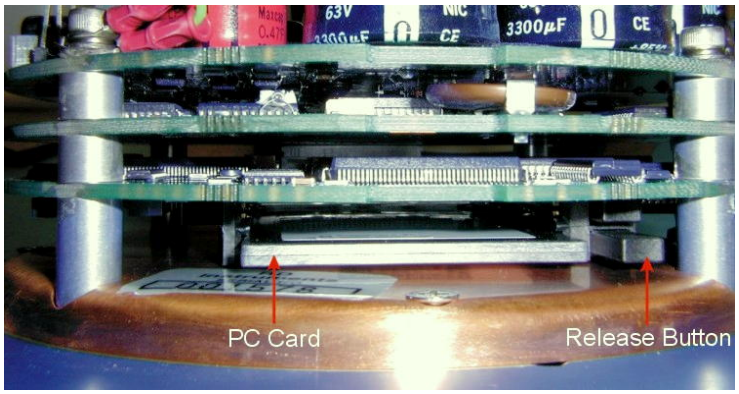

Figure 27. PC Card Recorder

d. When you are finished recovering the data, install the PC card back into the DSP board. PC cards install with the label side toward the face of the transducer.

e. Install the transducer head (see "Transducer Head Assembly Replacement," page 51).

NOTE. TRDI uses 12 or 16 FAT PCMCIA/ATA, 5-volt, type 2 memory cards made by Simple Tech. Other cards may work.

Do not use a PCMCIA adapter for compact flash cards. These do not work.

CAUTION. Do not delete files from the PC card using Windows®. This may leave hidden files on the card. Always use the ADCP's erase command to delete data from the PC card recorder.

3.12 Desiccant Bags

Desiccant bags are used to dehumidify the housing interior. Desiccant is essential in deployments with plastic housings. The factory-supplied desiccant lasts a year at specified Workhorse deployment depths and temperatures. Remember that desiccant rapidly absorbs moisture from normal room air.

The average dry weight of a new desiccant bag is 7.2 grams ((5%). The weight increases to 8.4 to 9 grams for a "used" desiccant bag. Used desiccant bags may be dried at 250° for 14 hours. As a minimum, replace the desiccant bags (Table 13, page 76, item 6) whenever you are preparing to deploy or store the Workhorse for an extended time.

CAUTION. Do not open the desiccant bag. Contact with the silica gel can cause nose, throat, and skin irritation.

NOTE. Desiccant bags are shipped in an airtight aluminum bag to ensure maximum effectiveness. There is a moisture indicator inside the bag. If the moisture indicator is pink, do not use the desiccant bag until it has been dried. TRDI recommends replacing the desiccant bag just before the deployment.

a. Remove the transducer head (see "Transducer Head Assembly Removal," page 48).

b. Remove the new desiccant bags from the airtight aluminum bag.

c. Remove the old desiccant bags and install two new ones. Place the desiccant bags (Table 13, page 76, item 6) between the PIO board and the end-cap.

d. Install the transducer head (see "Transducer Head Assembly Replacement," page 51).

3.13 Sealing the Workhorse for a Deployment

Use the "Parts Location Drawings," page 77 and the following steps to seal the Workhorse for a deployment.

a. Check the Workhorse electronics; there should be no loose screws or missing hardware.

b. Install the PC card(s) (Sentinel ADCPs only, see "PC Card Recorder," page 66)

c. Replace the battery pack or connect the battery cable (Sentinel ADCPs only, see "Sentinel Battery Packs," page 55)

d. Add two fresh desiccant bags inside the Workhorse housing (see "Desiccant Bags," page 67).

e. Install the transducer head assembly and end-cap (see "Workhorse Re-assembly," page 48).

f. The Workhorse is now ready for deployment unless you want to take steps to prevent biofouling (see "Prevention of Biofouling," page 68).

g. Use the appropriate ADCP User's Guide to connect the Workhorse system. Use "Testing the WorkHorse," page 95 to test the Workhorse before the deployment.

3.14 Prevention of Biofouling

This section explains how to prevent the buildup of organic sea life (biofouling) on the transducer faces. Objects deployed within about 100 meters (≈328 feet) of the surface are subject to biofouling, especially in warm, shallow water.

Deep Water Deployments. Biofouling is not usually a problem in deep water (more than 100 meters). Soft-bodied organisms usually cause no problems. Do not apply antifouling grease if deploying the WorkHorse in deep water.

Shallow Water Deployments. Soft-bodied organisms usually cause no problems, but barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the WorkHorse (see Figure 28, page 69).

In shallow-water applications, the use of antifouling grease may be appropriate if you cannot clean the transducer faces often (weekly), and if the antifouling grease meets all of your local safety and environmental laws.

3.14.1 Controlling Biofouling

The best-known way to control biofouling is cleaning the WorkHorse transducer faces often. However, in many cases this is not possible. The following options can help reduce biofouling.

- Coat the entire WorkHorse with the recommended antifouling paint. Make sure that the paint is applied in an even coat over the transducer faces.
- Apply a thin coat (≈4 mm; ≈0.16 in.) of either a 50:50 mix of chili powder and petroleum jelly or chili powder and silicone grease to the transducer faces. The chili powder should be the hottest that can be found. Water flowing across the transducers will wash this mix away over time. The silicone mixture tends to last longer.

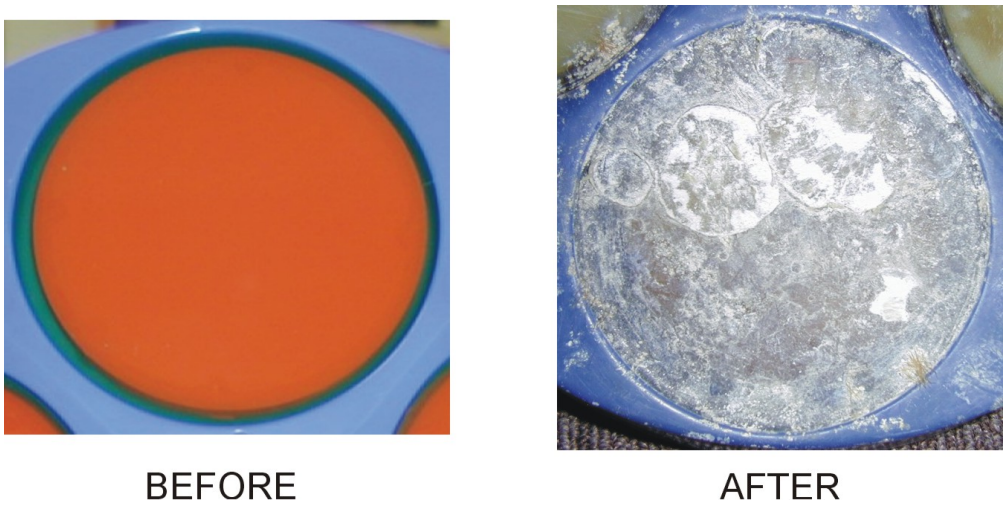

Figure 28. Barnacle Damage

CAUTION. Barnacles can cut through the urethane transducer face causing failure to the transducer and leakage into the WorkHorse.

If using antifouling grease, remove the grease immediately after recovering the WorkHorse from its deployment. Remove the grease with soapy water. Be sure to wear protective gloves and a face shield.

CAUTION.

1. Do not arbitrarily use antifouling grease for deep-water applications. For shallow-water applications, barnacles are a threat to the transducer faces; using antifouling grease may be appropriate if you cannot clean the WorkHorse regularly (weekly). If using antifouling grease, remove it immediately after recovering the WorkHorse.

2. Antifouling grease is toxic. Read the product safety data sheet before using the grease. Wear gloves and a face shield when applying the grease. If the skin comes in contact with the grease, immediately wash the affected area with warm, soapy water.
3. All U.S. coastal states prohibit the use of tributyl-tins on boat hulls. The European Economic Commission has released a draft directive that would prohibit the use of many organo-tins after July 1989. We strongly recommend you obey your local laws.

3.14.2 Recommended Antifouling Paints

You can use almost any EPA approved anti-fouling paint on the housing or the urethane transducer faces. You do have to be extra careful with the urethane faces. Interlux is one source of antifouling paint.

Manufacturer	Contact
Courtalds Finishes	Telephone: 908-686-1300
Interlux brand paints	Web Page : www.interlux.com

3.14.3 Applying Antifouling Paints

Follow the urethane faces application instructions. One thin coat can last for several months.

NOTE. If you have an optional WorkHorse pressure sensor, and you want pressure (depth) data, you cannot protect the pressure sensor from biofouling. The pressure sensor is located near the center of the transducer array, between the urethane-covered transducers. The sensor port is a small hole drilled through a screw (see "Pressure Sensor Maintenance," page 72). You should tape off the screw during anti-fouling paint application.

This means that the sensor port is not fully protected from bio fouling. The sensor port is surrounded by the antifouling paint, but bio fouling may build up on the screw, and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive. If it is logistically possible to periodically inspect/clean the pressure sensor screw, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

Transducer Faces (urethane surfaces) and Plastic Housing

a. Preparation - Lightly sand by hand with 120-grit paper.

b. Application - Apply one or two coats of anti-fouling paint at four mil/coat. If applying a second coat, wait at least 12 hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.

Metal Surfaces (High Pressure Systems)

a. Metal Surface Preparation

   1. On bare aluminum metal, use 353/354 Vinylux solvent wash (thin with 355). Perform the Metal Surface Application (Step (b), below) between 1 and 24 hours.
   2. On painted surfaces, use 120-grit sandpaper to remove gloss.

b. Metal Surface Application

   1. Mask as necessary.
   2. Apply one or two coats of anti-fouling paint (active ingredient is copper thiocyanate) at four mil/coat. If applying a second coat, wait at least 12 hours to allow the first coat to dry. One coat lasts one season (3-4 months); two coats might last one year.

NOTE. Do NOT use cuprous oxide on or near aluminum systems.

Figure 29. Antifouling Paint Applied to a WorkHorse Sentinel

3.15 Thermistor Maintenance

In order to respond quickly to changes in the water temperature, water must be able to flow over the sensor. Do not block the sensor or paint over it with antifouling paint. Remove any biofouling as soon as possible.

NOTE. The Thermistor is embedded in the transducer head. The sensor is under a titanium cover that is highly resistant to corrosion.

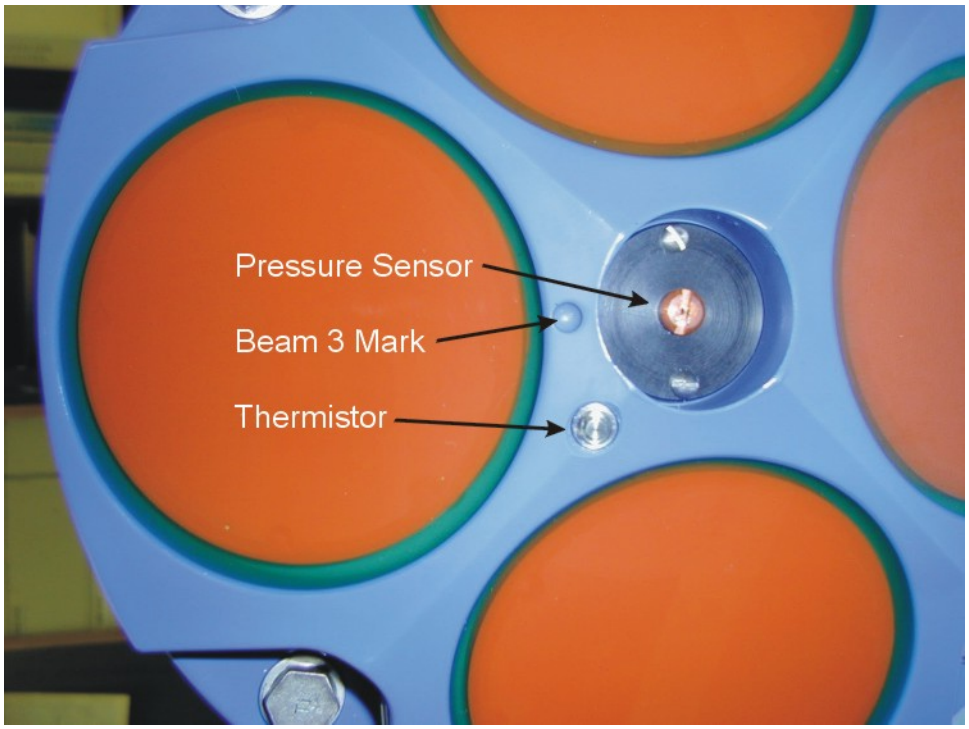

Figure 30. Thermistor and Pressure Sensor

3.16 Pressure Sensor Maintenance

In order to read the water pressure, water must be able to flow through the copper screw on the pressure sensor. The tiny hole in the copper screw may at times be blocked. Use the following procedure and Figure 31, page 73 to clean the screw.

NOTE. The pressure sensor is optional. It may not be included on your system.

a. Place the ADCP on its' end-cap. Use a soft pad to protect the ADCP.

b. Use a straight-slot screwdriver to remove the copper screw.

c. Gently clean out the hole in the copper screw with a needle. If the hole becomes enlarged or the screw is corroded, replace the screw. A replacement copper screw is included in the spare parts kit (part number 817-1067-00).

d. Install the copper screw. Tighten the screw "finger tight" (2 in/lbs). Do not over tighten the screw or you may strip the threads on the plastic cover disc. If this happens, return the ADCP to TRDI for repair.

CAUTION.

The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper screw while the screw is installed over the pressure sensor. You will perforate the sensor, causing it to fail.

Do not remove the cover disc or attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

Do not remove the pressure sensor. It is not field replaceable.

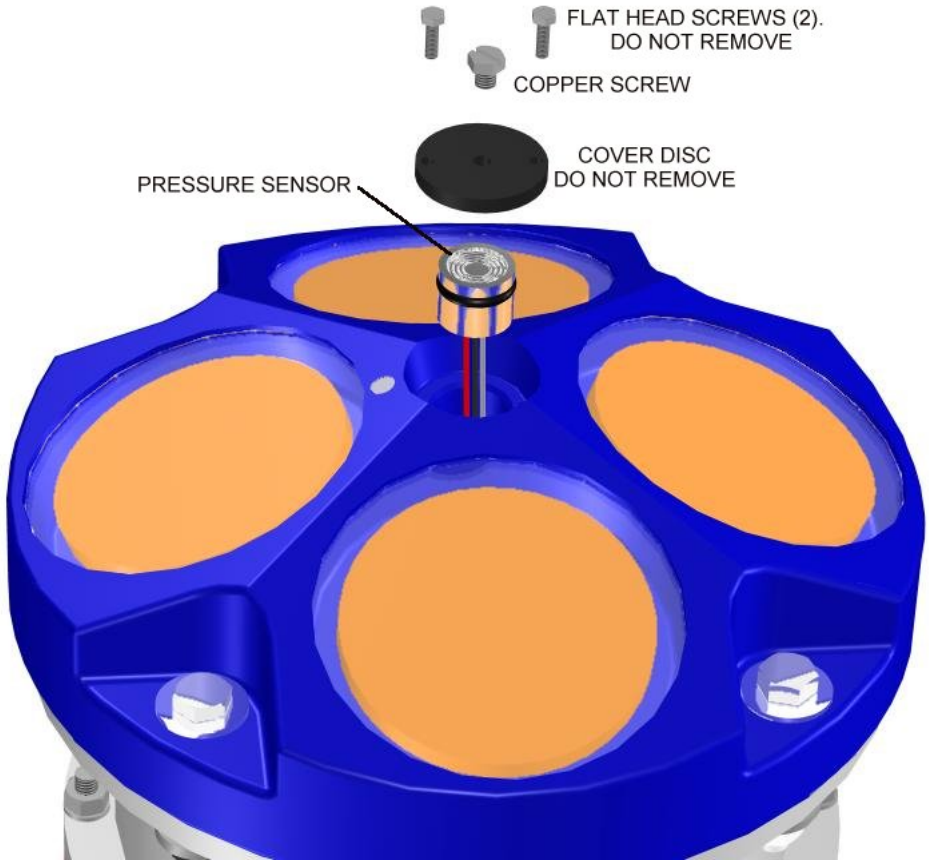

Figure 31. Workhorse Pressure Sensor (Exploded View)

3.17 Storage and Shipping Maintenance

This section lists the maintenance items to do before storing the Workhorse. These maintenance items include:

- Removing biofouling (see "Removal of Biofouling," page 74).
- Inspecting the transducer head (see "Transducer Head Inspection," page 74).
- Preparing the Workhorse for final storage or shipping (see "Final Storage or Shipping Preparation," page 75).

3.17.1 Removal of Biofouling

Before storing or shipping the Workhorse, remove all foreign matter and biofouling. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. Rinse with fresh water to remove soap residue. Dry the transducer faces with low-pressure compressed air or soft lint-free towels.

CAUTION. The soft, thin urethane coating on the transducer faces is easily damaged. Do not use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems, or brushes stiffer than hand cleaning brushes on the transducer faces.

If there is heavy fouling or marine growth, the transducer faces may need a thorough cleaning to restore acoustic performance. Barnacles do not usually affect Workhorse operation. We do however recommend removal of the barnacles to prevent water leakage through the transducer face. Lime dissolving liquids such as Lime-Away® break down the shell-like parts. Scrubbing with a medium stiffness brush usually removes the soft-bodied parts. Do NOT use a brush stiffer than a hand cleaning brush. Scrubbing, alternated with soaking in Lime-Away®, effectively removes large barnacles. After using Lime-Away®, rinse the Workhorse with fresh water to remove all residues. If barnacles have entered more than 1.0 to 1.5 mm (0.06 in.) into the transducer face urethane, you should send the Workhorse to TRDI for repair (see Figure 28, page 69). If you do not think you can remove barnacles without damaging the transducer faces, contact TRDI.

3.17.2 Transducer Head Inspection

The urethane coating on the transducer faces is important to Workhorse watertight integrity. Mishandling, chemicals, abrasive cleaners, and excessive depth pressures can damage the transducer ceramics or urethane coating. Inspect the transducer faces for dents, chipping, peeling, urethane shrinkage, hairline cracks, and damage that may affect watertight integrity or transducer operation. Repair of the transducer faces should only be done by TRDI.

CAUTION. Never set the transducer on a rough surface; always use foam padding to protect the transducers.

3.17.3 Final Storage or Shipping Preparation

This section explains how to store or ship the Workhorse. Clean and inspect the I/O connector for water or salt residue.

CAUTION. If you are shipping a Workhorse to TRDI for repair or upgrade, remove all customer-applied coatings or provide certification that the coating is nontoxic. This certification must include the name of a contact person who is knowledgeable about the coating, the name, and manufacturer of the coating, and the appropriate telephone numbers. If you return the equipment without meeting these conditions, we have instructed our employees not to handle the equipment and to leave it in the original shipping container pending certification. If you cannot provide certification, we will return the equipment to you or to a customer-specified cleaning facility. All costs associated with customer-applied coatings will be at the customer's expense.

When shipping the Workhorse through a Customs facility, be sure to place the unit/s so identifying labels are not covered and can be seen easily by the Customs Inspector. Failure to do so could delay transit time.

NOTE. TRDI strongly recommends using the original shipping crate whenever transporting the Workhorse.

If you need to ship or store the Workhorse, use the original shipping crate whenever possible. If the original packaging material is unavailable or unserviceable, additional material is available through TRDI.

For repackaging with commercially available materials, use the following procedure:

a. Use a strong shipping container made out of wood or plastic.

b. Install a layer of shock-absorbing static-shielding material, 70-mm to 100-mm thick, around all sides of the instrument to firmly cushion and prevent movement inside the container.

c. Seal the shipping container securely.

d. Mark the container FRAGILE to ensure careful handing.

e. In any correspondence, refer to the Workhorse by model and serial number.

3.18 Spare Parts

Table 13: Workhorse Spare Parts

Item #	Part #	Qty	Description
1.	2-260	4	O-Ring, Face Seal, Duro 70 EPDM
2.	717-3008-00	1	Jumper, GND, Main Electronics
3.	817-1067-00	1	Screw, Pressure Sensor, Workhorse
4.	817-3003-00	4	Washer, Felt Workhorse Electronics
5.	DC-111	1	Lubricant, Silicone1, 5.3oz Tube
6.	DES3	1	Desiccant, Sealed Bag
7.	GMA-3A	2	Fuse, 5mm X 20mm 3A 250V
8.	M6WASHSPLTI	2	Washer, 6mm Split Lock Titanium
9.	M6WASHSTDTI	4	Washer, Flat, Titanium 12.5mm OD
10.	M6X1.0NUTTI	2	Nut, Hex, Titanium 10mm
11.	M6X1.0X45HHTI	2	Screw, Hex Head, Titanium
12.	M8WASHSPLTI	2	Washer, Split Lock, Titanium
13.	M8WASHSTDTI	4	Washer, Flat, Titanium 12.5mm OD
14.	M8X1.25NUTTI	2	Nut, Hex, Titanium 13mm
15.	M8X1.25X65HHTI	2	Screw, Hex Head, Titanium
16.	SPR84-1LB	4	Rubber Band

3.19 Parts Location Drawings

Use the following figures to identify the parts used on your WorkHorse ADCP.

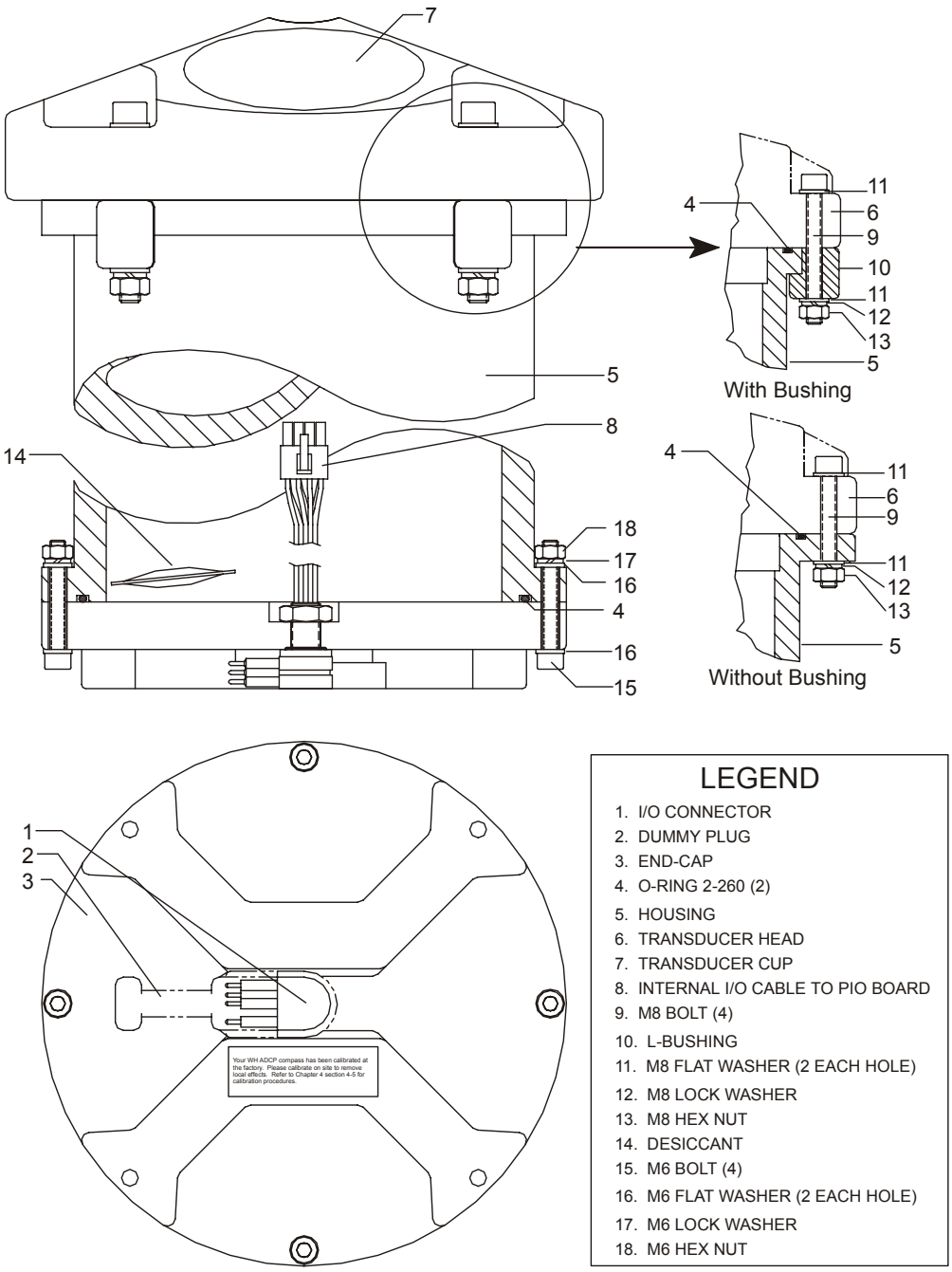

Figure 32. Mariner/Monitor Parts Location (200 and 500 Meter Systems)

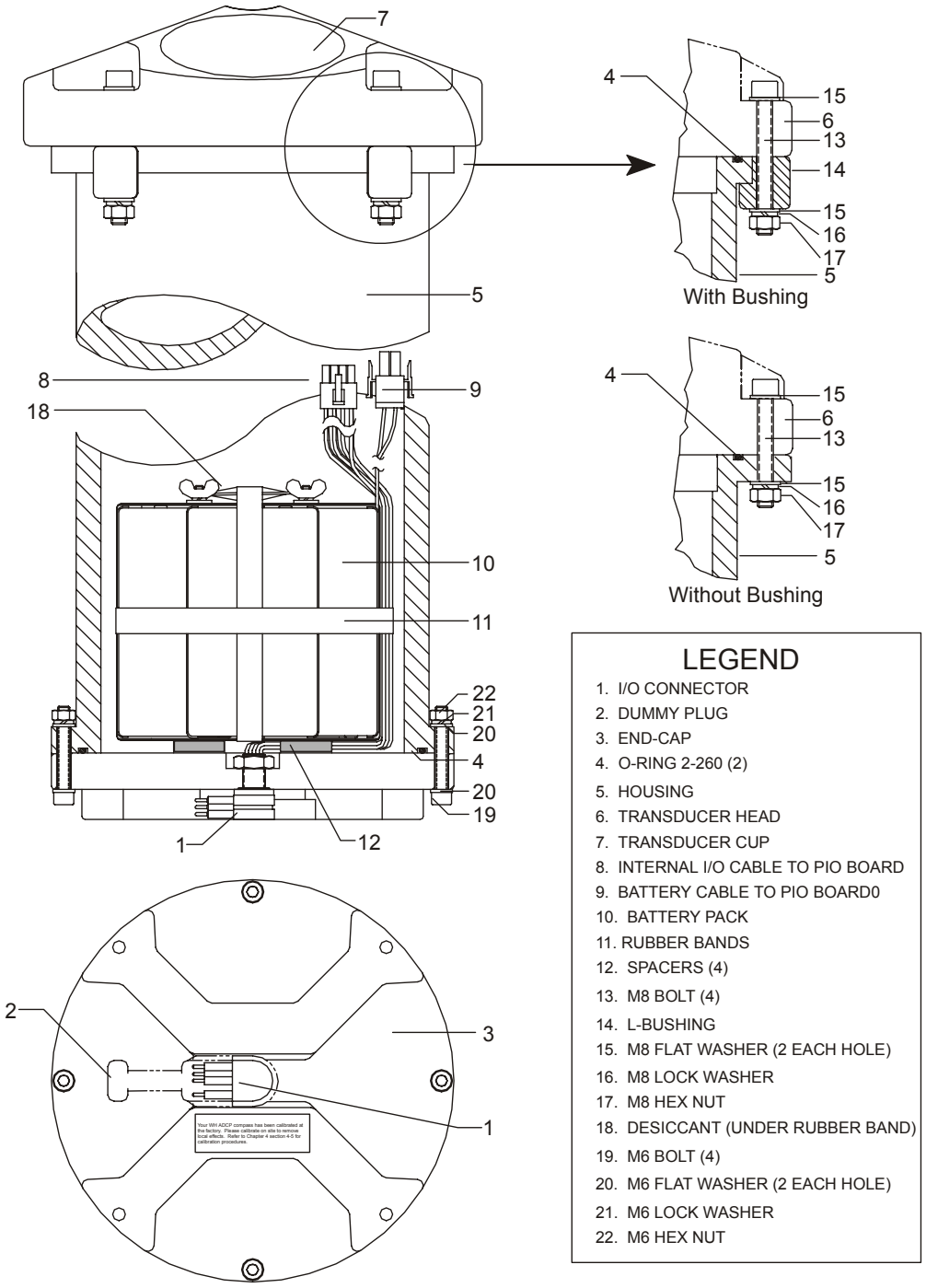

Figure 33. Sentinel Parts Location (200 and 500 Meter Systems)

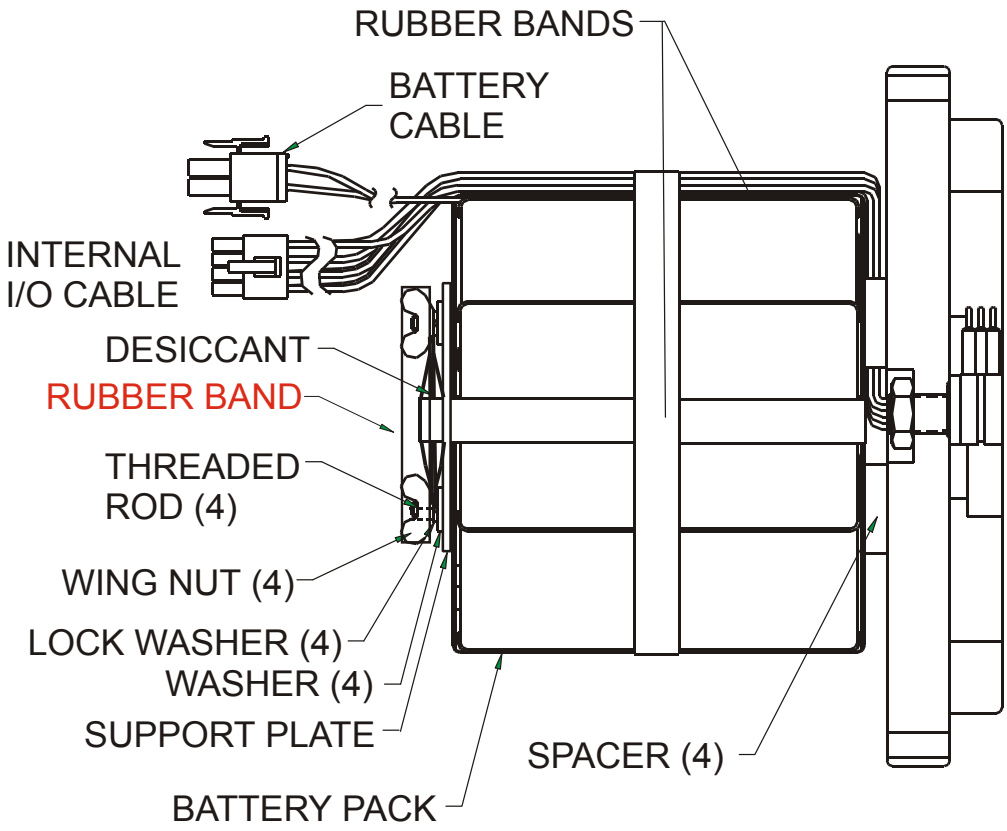

Figure 34. Sentinel End-cap and Battery Pack Parts Location

CAUTION. The Workhorse Sentinel battery packs are held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. **This has caused the PIO board to short out.** Place a rubber band around the four wing nuts to help hold them in place.

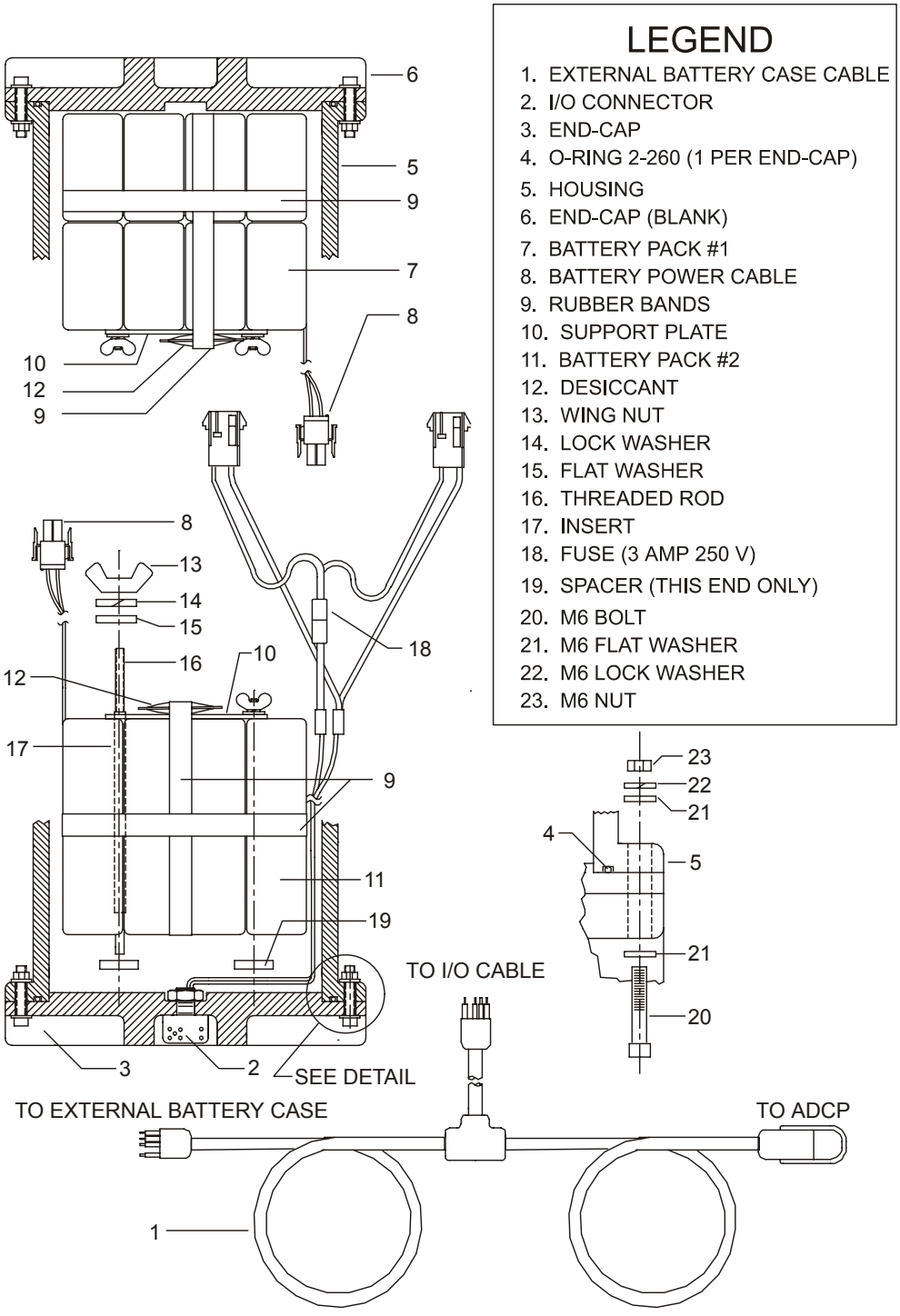

Figure 35. External Battery Pack Parts Location

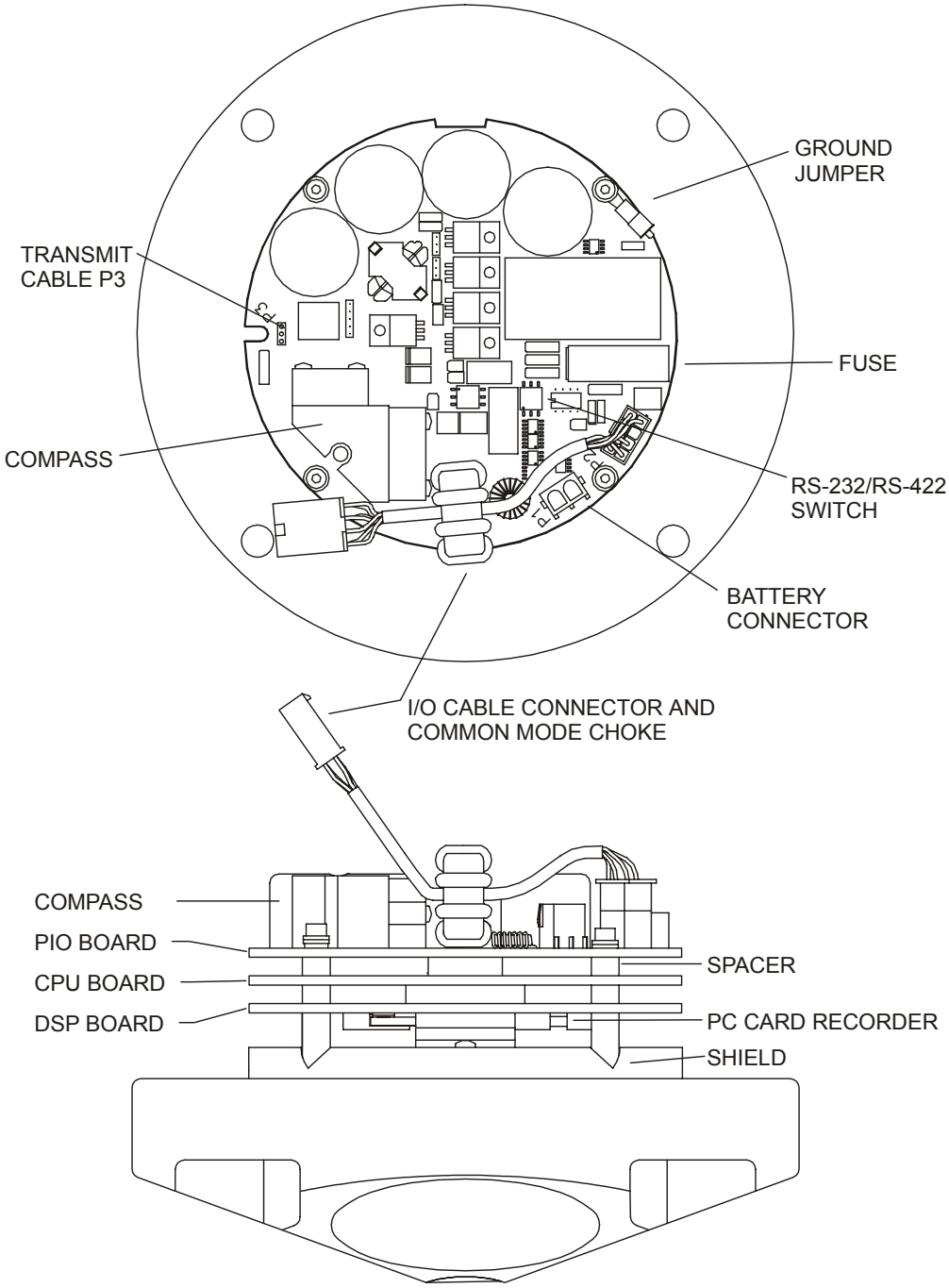

Figure 36. Workhorse Board Locations

3.20 High Pressure Housings

The high pressure housing upgrade allows you to deploy the ADCP in depths of 500, 1000, 3000, and 6000 meters. The "Outline Installation Drawings," page 157 shows the dimensions and weights for all of the systems.

This section includes information on installation, removal, and maintenance items for the high-pressure housing only.

3.20.1 High-Pressure Housing Disassembly

This section explains how to remove and replace the high-pressure end-cap or transducer head to gain access to the ADCP's electronics, batteries, and internal recorder. Read all instructions before doing the required actions.

High-Pressure End-Cap Removal Procedures

To remove the end-cap, do the following steps. Use "High-Pressure Parts Location Drawings," page 92 for parts identification.

NOTE. When you need access to the electronics, TRDI recommends removing the transducer head assembly (see "High-Pressure End-Cap Removal Procedures," page 82).

NOTE. The 3000 and 6000 meter housing is one piece. Follow the "High-Pressure Transducer Head Assembly Removal," page 83 to remove the housing.

a. Dry the outside of the Workhorse.

b. Stand the Workhorse on its transducer face on a soft pad.

c. Remove all power to the Workhorse.

d. Remove the I/O cable and place the dummy plug on the I/O cable connector (see "I/O Cable and Dummy Plug," page 45).

CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four end-cap bolts (6-mm) to vent the system.

a. Loosen (do not remove) the four end-cap bolts to vent the system.

b. Once all four end-cap bolts (6-mm) have been loosened, remove the bolts from the end-cap.

NOTE. Make sure you save all hardware removed during this procedure for re-assembly.

e. Carefully pull the end-cap away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the

plastic mating surfaces scratch easily. Do not damage the mating surfaces.

f. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap aside.

g. Remove any water from the end-cap O-ring grooves with a soft, lint-free cloth. Clean the O-ring mating surfaces. Inspect the surfaces for damage. Even small scratches can cause leakage around the O-ring seal.

High-Pressure Transducer Head Assembly Removal

a. Remove all power to the Workhorse.

b. Remove the I/O cable and place the dummy plug on the I/O cable connector (see "I/O Cable and Dummy Plug," page 45).

c. Stand the Workhorse on its end-cap.

CAUTION. If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing. As a precaution, loosen the four bolts (8-mm) to vent the system.

a. Loosen (do not remove) the four bolts (8-mm) that attach the housing flange to the transducer head assembly to vent the system.

b. Once all four bolts (8-mm) have been loosened, remove the bolts.

d. Carefully lift the transducer assembly straight up and away from the housing until you can gain access to the connector jack on the common mode choke. Use care; the plastic mating surfaces scratch easily. Do not damage the mating surfaces.

NOTE. The cable attached to the end cap is only long enough to disconnect the internal I/O cable. There is NOT enough cable to set the transducer down next to the Housing Assembly.

e. Squeeze the sides of the internal I/O cable connector to release it from the common mode choke jack. Set the end-cap assembly aside. Set the transducer assembly (transducer face down) on a soft pad.

f. Clean the O-ring mating surfaces with a soft, lint-free cloth. Inspect the surfaces for damage.

g. When you are ready to re-assemble the workhorse, see "High-Pressure Workhorse Re-assembly," page 84.

3.20.2 High-Pressure Workhorse Re-assembly

To replace the end-cap and transducer head, proceed as follows. Use the "High-Pressure Parts Location Drawings," page 92 for parts identification.

a. If you are sealing the Workhorse for a deployment, be sure you have done all appropriate maintenance items (see "Sealing the Workhorse for a Deployment," page 68).

b. Make sure all printed circuit boards, spacers, cables, and screws have been installed.

c. Install two fresh bags of desiccant just before closing the Workhorse (see "Desiccant Bags," page 67).

3.20.3 High-Pressure O-ring Inspection & Replacement

This section explains how to inspect/replace the Workhorse O-rings. A successful deployment depends on the condition of two O-rings and their retaining grooves. See "High-Pressure Parts Location Drawings," page 92 for the locations of the following O-rings. Read all instructions before doing the required actions.

500 meter housings

- Transducer assembly, face, 2-260
- End-cap assembly, face, 2-260

1000, 3000, and 6000 meter high-pressure housings

- Transducer and end-cap assembly, bore 2-258
- Transducer and end-cap assembly, face 2-261
- Transducer assembly, backup O-ring, 8-258 N300-90

NOTE. The backup O-ring is installed on 1000, 3000, and 6000 meter high-pressure housing systems in addition to the 2-258 bore O-ring on the transducer head assembly. Install the backup O-ring with the cupped side facing the 2-258 bore seal O-ring.

We strongly recommend replacing these O-rings whenever you disassemble the Workhorse. Inspecting and replacing the O-rings should be the last maintenance task done before sealing the Workhorse.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

a. Inspect the O-rings. When viewed with an unaided eye, the O-rings must be free of cuts, indentations, abrasions, foreign matter, and flow marks. The O-ring must be smooth and uniform in appearance. Defects must be less then 0.1 mm (0.004 in.).

CAUTION. If the O-ring appears compressed from prior use, replace it. **Weak or damaged O-rings will cause the ADCP to flood.**

b. Clean and inspect the O-ring grooves. Be sure the grooves are free of foreign matter, scratches, indentations, corrosion, and pitting. Run your fingernail across damaged areas. If you cannot feel the defect, the damage may be minor; otherwise, the damage may need repair.

CAUTION. Check the O-ring grooves thoroughly. **Any foreign matter in the O-ring grooves will cause the ADCP to flood.**

c. Lubricate the O-ring with a thin coat of DC-111 lubricant (Table 13, page 76, item 5). Apply the lubricant using latex gloves. Do not let loose fibers or lint stick to the O-ring. Fibers can provide a leakage path.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

d. The backup O-ring (see Figure 37, page 86) is installed in addition to the 2-258 bore O-ring on the transducer head assembly for 1000, 3000, and 6000-meter high-pressure systems only. Install the backup O-ring with the cupped side facing the 2-258 bore seal O-ring.

NOTE. During installation, do not cut or twist the O-ring. Never force O-rings over sharp corners, screw threads, keyways, slots, or other sharp edges.

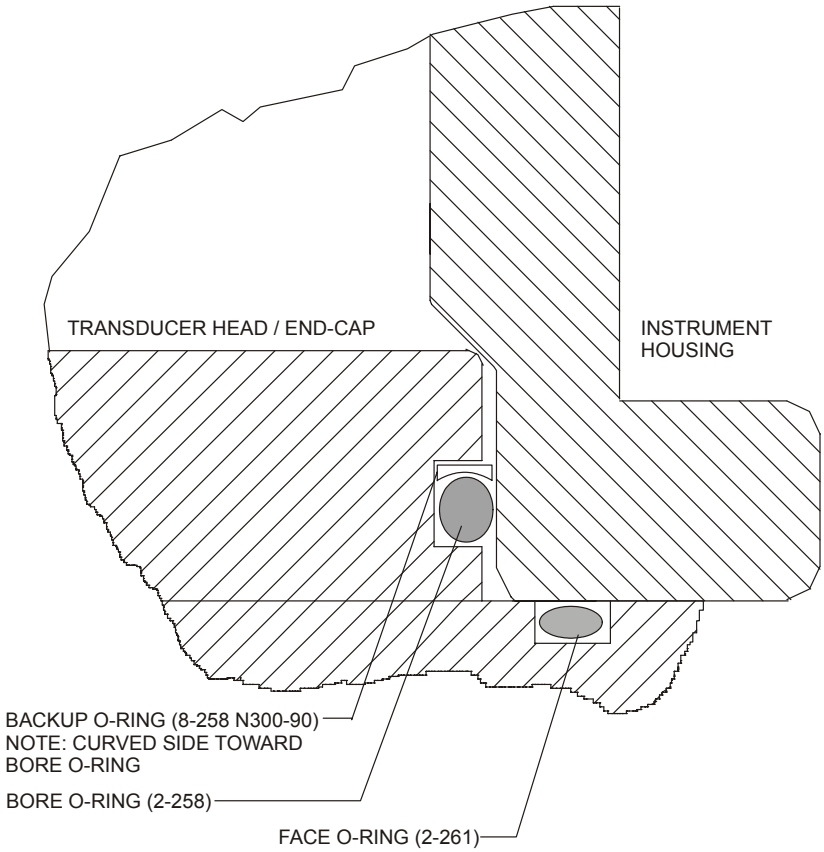

Figure 37. High Pressure O-Ring Detail View

High-Pressure End-cap Replacement

a. Stand the Workhorse on its transducer face on a soft pad.

b. Inspect, clean, and lubricate the face and bore O-rings on the end-cap. Apply a very thin coat of silicone lube on the O-rings.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

c. Connect the internal I/O connector to the plug on the common mode choke.

d. Place the end-cap on the housing, aligning the mating holes and the beam 3 number embossed on the end-cap with the beam 3 number embossed on the transducer head. When mating the end-cap with the housing flange, try to apply equal pressure to all parts of the O-rings. Make sure the face and bore O-rings remain in the retaining groove.

CAUTION. Check that no wires or any other object is pinched between the end-cap and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

e. Examine the end-cap assembly nuts, bolts, and washers (6 mm) for corrosion; replace if necessary. The "High-Pressure Parts Location Drawings," page 92 shows the assembly order of the end-cap mounting hardware. All the hardware items are needed to seal the Workhorse properly.

f. Install all four sets of hardware until "finger-tight."

g. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).

CAUTION. Apply equal pressure to the O-rings as you tighten the bolts. If one bolt is tightened more then the others, the O-rings can become pinched or torn. **Damaged O-rings will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic bushing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

High-Pressure Transducer Head Replacement

a. Stand the Workhorse on its end-cap.

b. Inspect, clean, and lubricate the O-rings on the transducer head flange. Apply a very thin coat of silicone lube on the O-ring.

NOTE. We recommend you use new O-rings if you are preparing for a deployment.

NOTE. TRDI uses Dow Corning's silicone lube model number 111 but any type of silicone O-ring lube can be used.

CAUTION. Apply a **very thin** coat of silicone lube on the O-ring. Using too much silicone lube on the O-ring can be more harmful than using no O-ring lube at all.

c. Connect the internal I/O connector to the plug on the common mode choke.

d. Gently lower the transducer head/electronics assembly into the housing, aligning the mating holes and the beam 3 number embossed on the transducer head with the beam 3 number embossed on the end-cap. When mating the housing with the transducer head flange try to apply equal pressure to all parts of the O-rings. Make sure the face and bore O-rings remain in the retaining groove.

CAUTION. Check that no wires or any other object is pinched between the transducer head and the housing. Use rubber bands to hold the wiring in place as necessary. **If the O-ring is not in the groove or if a wire or other object is pinched, the ADCP will flood.**

e. Examine the transducer assembly nuts, bolts, and washers (8-mm) for corrosion; replace if necessary. The "High-Pressure Parts Location Drawings," page 92 shows the assembly order of the transducer mounting hardware. All hardware items are needed to seal the Workhorse properly.

f. Install all four sets of hardware until "finger tight."

g. Tighten the bolts in small increments in a "cross" pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly. Tighten the bolts to the recommended torque value of 9.6 Newton-meters (85 pound-inches). Do not deform the plastic bushings.

CAUTION. Apply equal pressure to the O-rings as you tighten the bolts. If one bolt is tightened more then the others, the O-rings can become pinched or torn. **Damaged O-rings will cause the system to flood.**

CAUTION. Do not over tighten the bolts that hold the transducer, housing, and end cap together. If you tighten too far, you can crack or break the plastic bushing. On the other hand, leaving the bolts too loose can cause the system to flood. **Tighten the hardware to the recommended torque value.**

NOTE. The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

3.20.4 Zinc Anode Inspection and Replacement

High-pressure systems have up to twelve sacrificial zinc anodes. If the ADCP does not have exposed bare metal, properly installed anodes help protect the ADCP from corrosion while deployed. Read all instructions before doing the required actions.

Zinc Anode Inspection

The life of a zinc anode is not predictable. An anode may last as long as one year, but dynamic sea conditions may reduce its life. Use a six-month period as a guide. If the total deployment time for the anodes has been six months or more, replace the anodes. If you expect the next deployment to last six months or more, replace the anodes. Inspect the anodes as follows.

a. Inspect the anodes on the transducer assembly, housing and end-cap for corrosion and pitting. If most of an anode still exists, you may not want to replace it.

b. Inspect the RTV-covered screws that fasten each anode. If the RTV has decayed enough to let water enter between the screws and the anode, replace the RTV.

c. If you have doubts about the condition of the anodes, remove and replace the anode.

Zinc Anode Electrical Continuity Check

Check electrical continuity using a digital multimeter (DMM). All measurements must be less than five ohms. If not, reinstall the affected anode.

End-Cap Anode. Measure the resistance between all four anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

Housing Anodes. Measure the resistance between all four anodes. Scratch the surface of the anode with the DMM probe to make good contact if the anode is oxidized. The resistance should be less than five ohms.

Transducer Anode. Remove the housing. Measure the resistance between the anode and any one of the four screws holding the PC boards to the transducer. The resistance should be less than five ohms.

Zinc Anode Replacement

The following steps explain how to remove and replace the zinc anode/s.

a. Remove the RTV from the anode screw heads. Remove the screws.

b. The anode may stick to the ADCP because of the RTV used during assembly. To break this bond, first place a block of wood on the edge of the anode to protect the housing anodizing and paint. Carefully strike the block to loosen the anode.

c. Clean the bonding area under the anode. Remove all foreign matter and corrosion. Apply a continuous 1-2 mm bead (0.04-0.08 in.) of RTV around each screw hole.

d. Set a new anode in place and fasten with new screws.

e. Fill the counter bore above each screw head with RTV. The RTV protects the screw heads from water and prevents breaking the electrical continuity between the anode, screw, and housing.

f. Check electrical continuity. If any measurement is greater than one ohm, reinstall the affected anode.

CAUTION.

1. Do not use zinc anodes with an iron content of more than 0.0015%. The major factor controlling the electrical current output characteristics of zinc in seawater is the corrosion film that forms on the surface of the zinc. Corrosion product films containing iron have a high electrical resistance. As little as 0.002% iron in zinc anodes degrades the performance of the anode.

2. Do not use magnesium anodes. Magnesium rapidly corrodes the aluminum housing.

3. Do not connect other metal to the ADCP. Other metals may cause corrosion damage. Use isolating bushings when mounting the ADCP to a metal structure.

3.20.5 Protective Coating Inspection and Repair

TRDI uses paint on the housing for identification and corrosion protection. For more protection, the case and the transducer assembly are first anodized. Do not damage the surface coatings when handling the ADCP. Inspect and repair the protective coating as follows. Read all instructions before doing the required actions.

NOTE. The procedures contained in this section apply to our standard aluminum systems. For systems made of other materials, contact TRDI.

a. Inspect the end-cap, housing, and transducer assemblies for corrosion, scratches, cracks, abrasions, paint blisters, exposed metal (silver-colored

aluminum), exposed anodize (black or dark green), and exposed primer (yellow). Be critical in your judgment; the useful life of the WorkHorse depends on it.

CAUTION. The chemicals used in the following steps can be hazardous to your health. Read all material safety data sheets and manufacturer's instructions before handling these chemicals.

b. If you are familiar with the repair of anodized coatings, proceed as follows; otherwise, send the WorkHorse to TRDI for repair.

   1. Clean and prepare the damaged area using a fine-grade abrasive cloth or a fine-grade abrasive silicon carbide wheel. Remove all corrosion from the bare aluminum.
   2. Clean the area with alcohol. Do not touch the area after cleaning.
   3. Anodize per MIL-A-8625, Type 3, Class 1.
   4. Seal with sodium dichromate only.
   5. Paint repaired area as described in step c below.

c. Proceed as follows to repair or touch up the protective paint.

   1. Remove all loose paint without damaging the anodizing. Clean and prepare the damaged area using a fine-grade abrasive cloth. Feather the edges of the paint near the damaged area. Try to have a smooth transition between the paint and the damaged area. Do not sand the anodized area. If you damage the anodizing, see step b above for repair.
   2. Clean the area with alcohol. Do not touch the area after cleaning.
   3. Paint with one coat of epoxy primer (manufacturer's part number 4500; see note below).
   4. Paint with one coat of orange or black paint (manufacturer's part number 4512-B (orange), 4511-B (black); see note below).

NOTE. TRDI uses two-part epoxy type paint. This paint is manufactured by Pro-line Paint Manufacturing company, 2426 Main St., San Diego, CA, 92113, Telephone: +1 (619) 231-2313; or 1168 Harbor, Long Beach, CA, 98813, Telephone: +1 (213) 432-7961. Manufacturer's part numbers:

4500-A, Pro-thane Paint, Catalyst, Part A
4511-B, Pro-thane Paint, Black, Part B
4512-B, Pro-thane Paint, Orange, Part B

3.20.6 High-Pressure Systems Spare Parts

Table 14: High-Pressure Systems Spare Parts

Description	Vendor	Part #
O-ring, face seal, 2-261, EPDM, Duro	Cal State Seal +1 (619) 224-2007	2-261, EPDM, Duro 70, Parker
O-ring, bore seal, 2-258, EPDM, Duro	Cal State Seal	2-258, EPDM, Duro 70, Parker
O-ring, 8-258 N300-90, PARBAK	Cal State Seal	2-258, PARBAK
Bushing, L	TRDI	811-4007-00
M8 Bushing, plastic isolation	Use local vendor	

3.20.7 High-Pressure Parts Location Drawings

Use the following figures to identify parts used on your high-pressure WorkHorse ADCP.

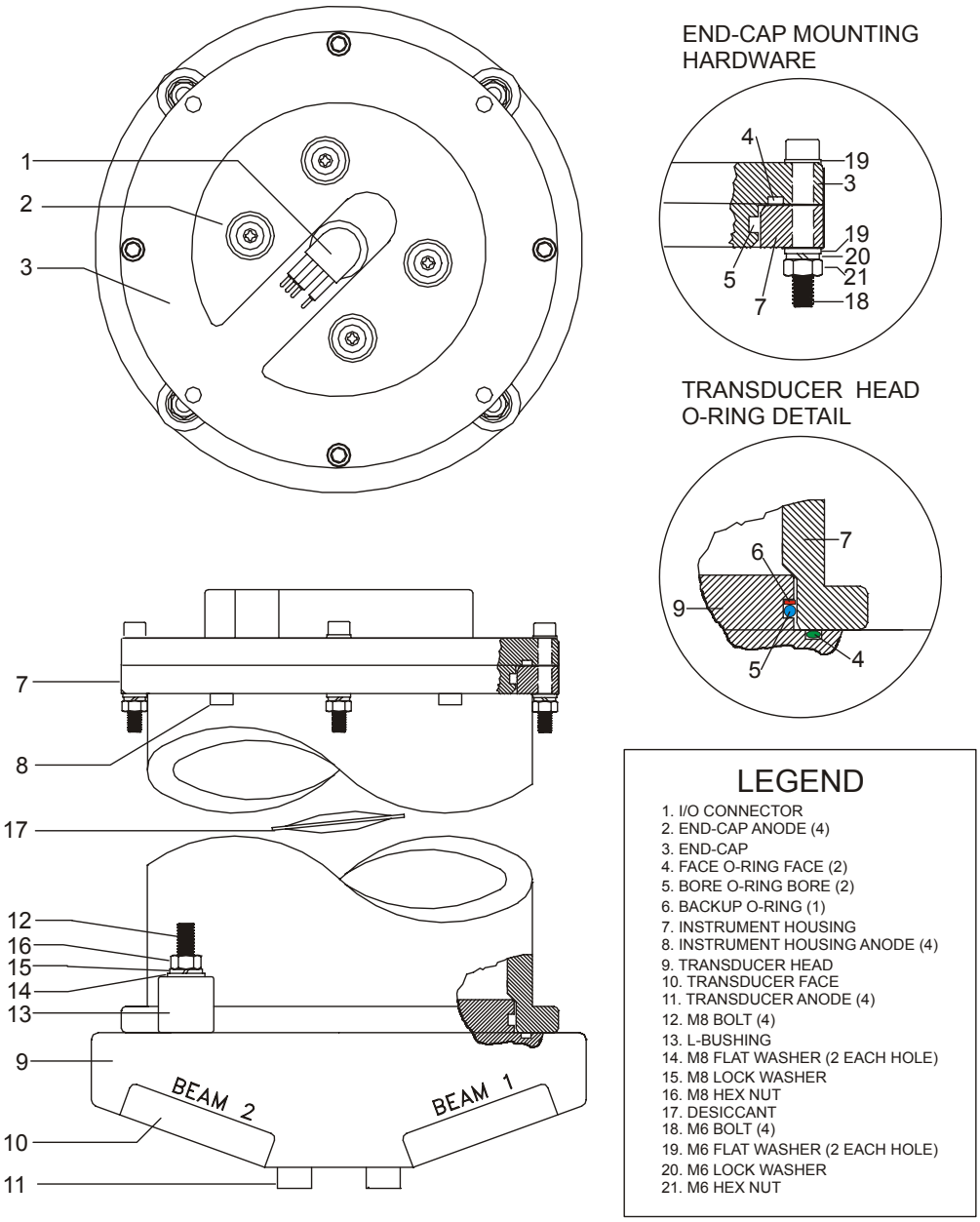

Figure 38. 1000 meter WorkHorse Parts Location

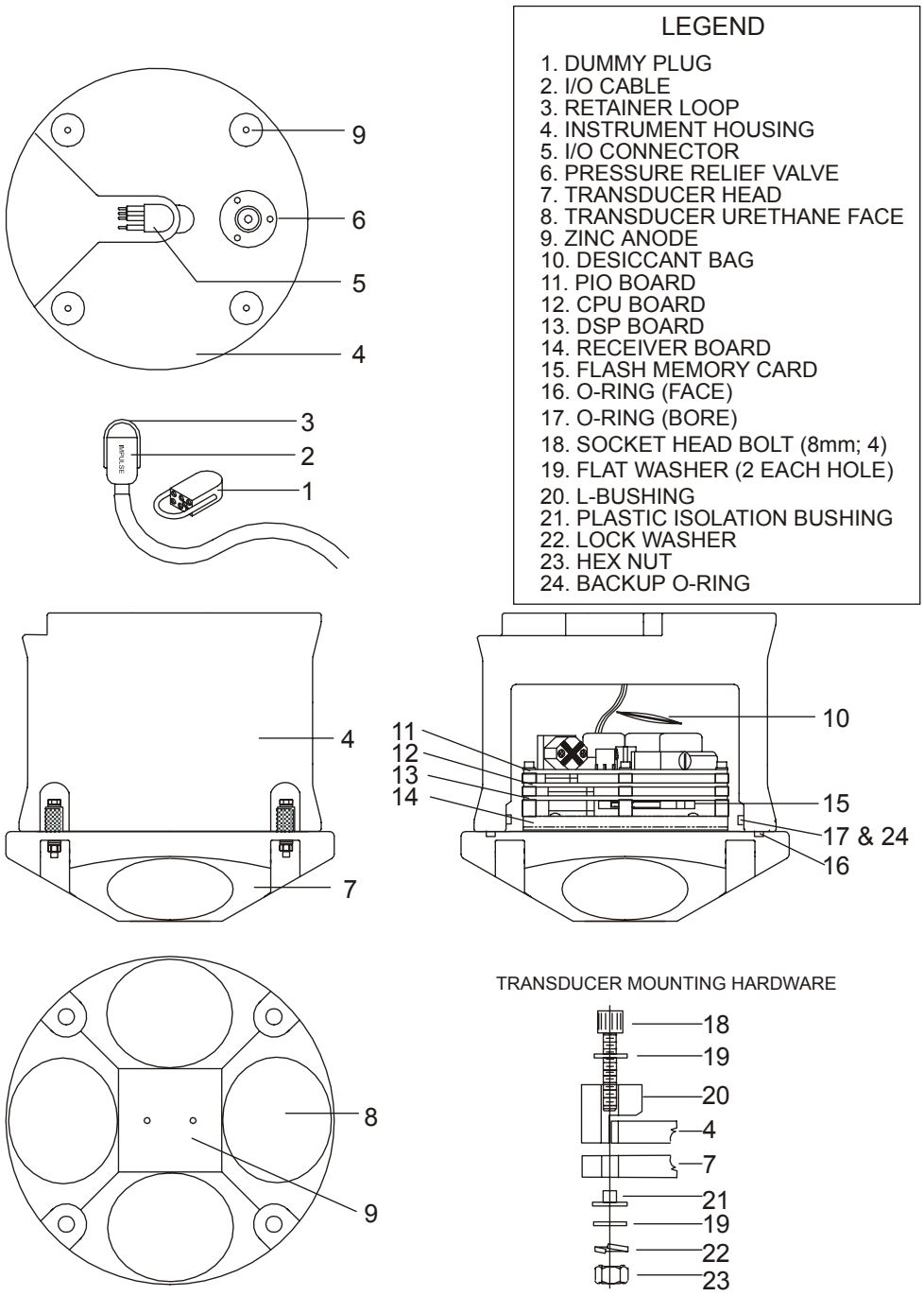

Figure 39. 3000 and 6000 meter WorkHorse Parts Location

4 Testing the WorkHorse

This chapter explains how to test the Workhorse using the *WinSC* and *BBTalk* programs. These tests thoroughly check the Workhorse in a laboratory environment, but are no substitute for a practice deployment. You should test the Workhorse:

- When you first receive the Workhorse.
- Before each deployment or every six months.
- When you suspect instrument problems.
- After each deployment.

These test procedures assume all equipment is working. The tests can help you isolate problems to a major functional area of the Workhorse. For troubleshooting information, see "Troubleshooting," page 116.

NOTE. For stationary deployments, the *WinSC* or *BBTalk* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side tests and the Sea Acceptance tests.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Care page (www.rdinstruments.com). Please check our web site often.

4.1 Testing the WorkHorse with *WinSC*

Use the following steps to test the ADCP.

NOTE. For stationary deployments, the *WinSC* or *BBTalk* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side test and the Sea Acceptance tests.

a. Connect and power up the ADCP as shown in the appropriate ADCP User's Guide.

b. Start *WinSC* (for help on using *WinSC*, see the *WinSC* User's Guide).

c. At the **Welcome** screen, click **Test an ADCP**. Click **OK**. This will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1-commands. The results of the tests will be printed to the screen and saved to the log file (*.scl).

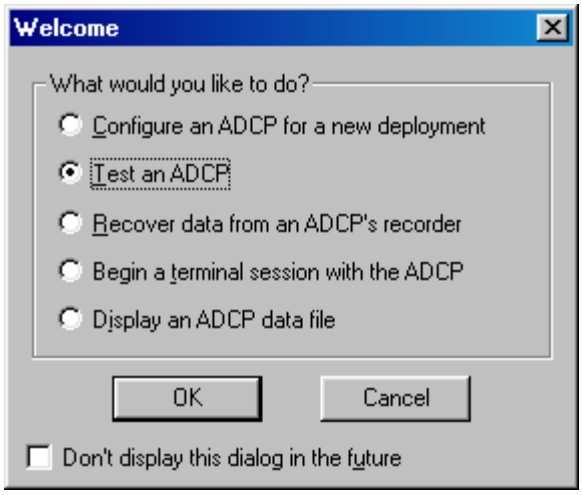

Figure 40. Using WinSC to Test an ADCP

4.2 Testing the WorkHorse with *BBTalk*

Use the following steps to test the ADCP.

NOTE. For stationary deployments, the *WinSC* or *BBTalk* tests are the only tests required to verify the ADCP is operating correctly. When the ADCP is mounted to a moving vessel, use the Dock Side test and the Sea Acceptance tests.

e. Interconnect and apply power to the system as described in the appropriate ADCP User's Guide.

f. Start the *BBTalk* program (for help on using *BBTalk*, see the RDI Tools User's Guide).

g. Press **<F2>** and run the script file TestWH.rds. The TestWH.rds script file runs PS0, PS3, PA, PC2, and the PC1 tests. The results of the tests will be printed to the screen and saved to the log file WH_RSLTS.txt. The WH_RSLTS.txt file will be created in the same directory that *BBTalk* is running from.

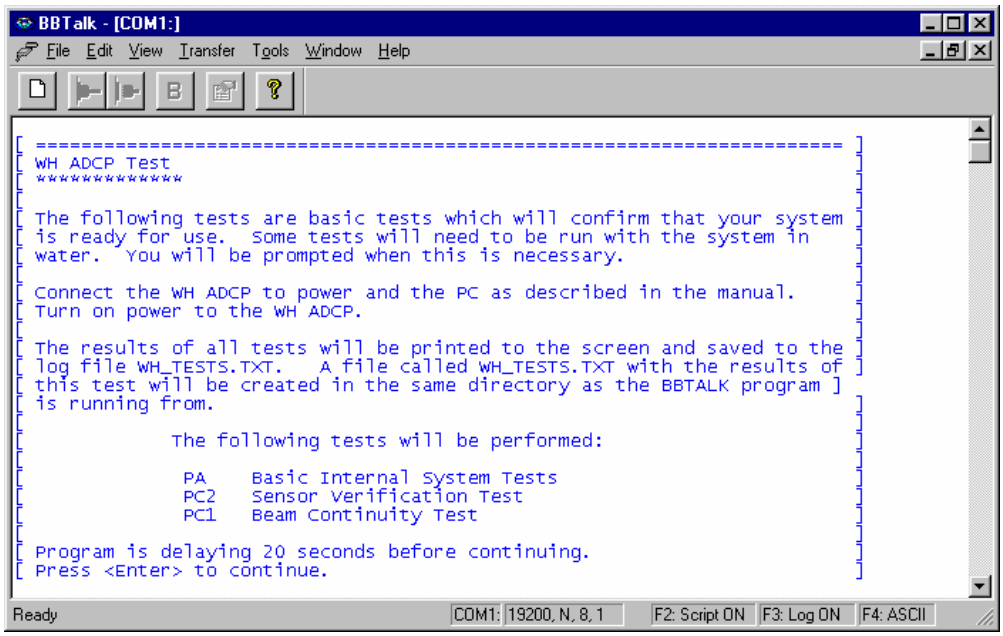

Figure 41. Using BBTalk to Test an ADCP

4.3 Test Results

This section shows an example of the test result printout after running the *WinSC* tests or the *BBTalk* script file TestWH.rds.

NOTE. The built-in tests require you to immerse the transducer faces in water. If you do not, some of the tests may fail. Running the tests in air will not harm the ADCP.

4.3.1 Deploy Commands List

WinSC sends the ADCP the Deploy? command. This will show a list of the deployment commands and their current setting. For example;

```
deploy?
Deployment Commands:
RE ------------------------ Recorder ErAsE
RN ------------------------ Set Deployment Name

WD = 111 100 000 --------- Data Out (Vel,Cor,Amp; PG,St,P0; P1,P2,P3)
WF = 0088 ---------------- Blank After Transmit (cm)
WN = 030 ----------------- Number of depth cells (1-128)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WS = 0200 ---------------- Depth Cell Size (cm)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)

BP = 000 ----------------- Bottom Track Pings per Ensemble

TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 94/01/30,00:11:17 --- Time Set (yr/mon/day,hour:min:sec)

EA = +00000 -------------- Heading Alignment (1/100 deg)
```

```
EB = +00000 -------------- Heading Bias (1/100 deg)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
ES = 35 ------------------ Salinity (0-40 pp thousand)
EX = 11111 --------------- Coord Transform (Xform: Type,Tilts,3 Bm,Map)
EZ = 1111101 ------------- Sensor Source (C,D,H,P,R,S,T)

CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CK ----------------------- Keep Parameters as USER Defaults
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Start Deployment
```

4.3.2 System Commands List

WinSC sends the ADCP the System? command. This will show a list of the system commands and their current setting. For example;

```
>system?
System Control, Data Recovery and Testing Commands:
AC ----------------------- Output Active Fluxgate & Tilt Calibration data
AF ----------------------- Field calibrate to remove hard/soft iron error
AR ----------------------- Restore factory fluxgate calibration data
AX ----------------------- Examine compass performance
AZ ----------------------- Zero pressure reading

CB = 411 ----------------- Serial Port Control (Baud; Par; Stop)
CP # --------------------- Polled Mode (0 = NORMAL, 1 = POLLED)
CZ  ---------------------- Power Down Instrument

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log

OL ----------------------- Display Features List

PA ----------------------- Pre-Deployment Tests
PC1 ---------------------- Beam Continuity
PC2 ---------------------- Sensor Data
PS0 ---------------------- System Configuration
PS3 ---------------------- Transformation Matrices

RR ----------------------- Recorder Directory
RF ----------------------- Recorder Space used/free (bytes)
RY ----------------------- Upload Recorder Files to Host
```

4.3.3 Time Set

WinSC sends the ADCP the TS? command. This will show the current setting of the real time clock. For example;

```
>TS?
TS = 98/06/17,07:31:27 --- Time Set (yr/mon/day,hour:min:sec)
>
```

4.3.4 Recorder Free Space

WinSC sends the ADCP the RS command. This will show the amount of used and free recorder space in megabytes. For example;

```
>RS
RS = 000,010 --------- REC SPACE USED (MB), FREE (MB)
>
```

4.3.5 Display System Parameters

This tells the ADCP to display specific information about your ADCP. Both *WinSC* and *BBTalk* run this test. For example:

```
>ps0
  Instrument S/N:  0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = -2.500000E-03
          Offset = +0.000000E+00

Temp Sens Offset:  -0.20 degrees C

    CPU Firmware:  16.xx
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   08  00 00 02 C9 20 A7  09 CPU727-2000-00H
   4D  00 00 00 D4 97 37  09 PIO727-3000-03C
>
```

Verify the information is consistent with what you know about the setup of your system. If PS0 does *not* list all your sensors, there is a problem with either the communications to the transducer or a problem with the receiver board.

4.3.6 Instrument Transformation Matrix

PS3 sends information about the transducer beams. Only the *BBTalk* script file TestWH.rds runs this test. The WorkHorse uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

If the WorkHorse has beam angle errors, they are reflected in the instrument transformation matrix and the Beam Directional matrix. This matrix, when multiplied by the raw beam data gives currents in the *x*, *y*, *z*, and *e* directions.

4.3.7 Pre-deployment Test

This diagnostic test checks the major WorkHorse modules and signal paths. Both *WinSC* and *BBTalk* run this test. For example, the output may look like this:

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

4.3.8 Display Heading, Pitch, Roll, and Orientation

The PC2 test displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Any key pressed exits this command and returns the user to the command prompt. Both *WinSC* and *BBTalk* run this test.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C         22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C         22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°     Up          24.37°C         22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°     Up          24.37°C         22.98°C        0.0 kPa
```

4.3.9 Beam Continuity

The PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed. Both *WinSC* and *BBTalk* run this test.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43

Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

NOTE. This test must be performed with the ADCP out of water and preferably dry.

4.4 Dock Side Tests

The following checks should occur at Dock Side prior to performing the Sea Acceptance Tests. These tests will verify the WorkHorse ADCP is ready for the Sea Acceptance Tests and confirm the peripherals attached to the ADCP.

NOTE. These tests only apply to moving vessel deployments.

4.4.1 Dock Side Diagnostic Test

The following test will confirm the connection of the WorkHorse Deck box (Mariner) to the Transducer or WorkHorse to the computer.

Table 15: Dock Side Test Setup

Setup	Description
Platform/Vessel	The vessel should be tied to the dock or at anchor. The transducer should be in water. All other sonar devices and equipment should be turned off.
WorkHorse	Connect the ADCP as described in the appropriate ADCP User's Guide. The Gyro/Navigation connection may or may not be connected at this point.
Computer	The TRDI *BBTalk* program should be running, communications port setting (F5) to match the connection to the PC and WorkHorse ADCP baud rate requirements (default 9600,N,8,1).

Use the following steps to interconnect the WorkHorse system and to place the ADCP in a known state.

a. Interconnect and apply power to the system as described in the appropriate ADCP User's Guide.

b. Start the *BBTalk* program.

c. Press **End** to wake up the ADCP. Send the PA command to the ADCP. See "Pre-deployment Test," page 100 for an example of the test result printout.

4.4.2 Dock Side Peripheral Tests

The WorkHorse requires (at minimum) input for heading (true north) and for position fixes (GPS). Additionally, the WorkHorse can make use of pitch and roll data to correct for the tilt.

Heading can be input directly to the WorkHorse deck box through an external synchro gyro or stepper gyro (Mariner only). Heading can also (or instead of) be input and combined with WorkHorse data in the computer software *VmDas*. This heading input is done through the communications port of the computer with the NMEA 0183 string $HDT or $HDG as specified in the **Transforms** tab in *VmDas*.

If the gyro connection is used for the heading input, then the Gyro Interface Board must be first configured to match the platform's gyro output. Follow the instructions in "Gyrocompass Interface Considerations," page 30 on how to setup the Gyro Interface Board.

Pitch and Roll data can be input directly to the Mariner deck box through an external synchro gyro. Pitch and Roll can also (or instead of) be input and combined with WorkHorse data in the computer software *VmDas*. This heading input is done through the communications port of the computer with the TRDI proprietary NMEA string $PRDID.

Navigation data can only be combined with WorkHorse data in the computer software *VmDas*. This navigation input is done through the communications port of the computer with the NMEA proprietary strings $GGA and $VTG.

NOTE. See the VmDas User's Guide and/or the WinRiver User's Guide for help on integrating NMEA Devices.

Table 16: Dock Side Peripheral Tests Setup

Setup	Description
Platform/Vessel	The Gyro, Navigation, and Pitch/Roll sensors should be attached to the appropriate place on either the WorkHorse deck box or the computer communication port. The devices should be on and should stable (in the case of gyros this may require a spin up time of up to 12 hours).
WorkHorse	The WorkHorse should be connected as described in the appropriate ADCP User's Guide, AC Power connected to the deck box/ADCP, and the power switch turned on.
Computer	The TRDI *BBTalk* program should be running, communications port setting (F5) to match the connection to the PC and WorkHorse ADCP baud rate requirements (default 9600,N,8,1).

Testing the Gyro Connections to the Deck box (Mariner Only)

The following sequence of commands should be sent after powering up the WorkHorse deck box. These commands will wake up the ADCP (<BREAK>), initialize the WorkHorse (CR1), and save the initialization (CK).

```
<BREAK> press the end key
CR1
CK
```

The following command should be sent to test the gyro input to the WorkHorse deck box.

```
PC2
```

The response from the ADCP should be as follows:

```
>PC2
Heading          Pitch      Roll        Temperature
 (ext)           (ext)      (ext)       cts     degs
 000.0           +00.0      +00.0       243E    23.9
```

Testing the Navigation Connections to the Compute (VmDas)r

Start *VmDas* in the Data Collect mode. On the **View** menu, select **NMEA Communications**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

The **Navigation Data** window in *VmDas* (see Figure 42) shows a text box of the position and velocity data from a NMEA navigation device. You can use this to verify the navigation connections.

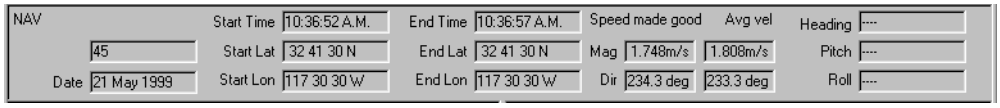

Figure 42. Testing the Navigation Connections

Testing $HDG Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $HDG string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing $PRDID Heading Connections to the Computer (VmDas)

Start *VmDas* in the Data Collect mode. On the **View** menu, select **Nmea Communications**. Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present. Note that the data for this information may appear on the same communications port as the navigation data or on a separate input port.

Testing the Navigation Connections to the Compute (WinRiver)r

Start *WinRiver* in the Acquire mode. On the **View** menu, select **Device Logs**. Confirm that the Navigation Device NMEA string is viewable and the $GGA string is present.

Table 17: Dock Side Peripheral Test Results

Test	Test Criterion
External Gyro Connection Test	Verify that the Gyro inputs for Heading, Pitch and Roll (if included) are reasonable for the platform's attitude. The Temperature reading should match the expected water temperature at the transducer.
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $GGA string is present.
External Heading NMEA Connection Test	Verify that the Navigation Device NMEA string is viewable and the $HDT or $HDG string is present.
External Heading NMEA Connection Test	Confirm that the Navigation Device NMEA string is viewable and the $PRDID string is present.

4.5 Sea Acceptance Tests

This procedure is intended to test the WorkHorse at sea. This procedure assumes that the Dock Side Testing (see "Dock Side Tests," page 102) procedure has been run and that all of the items have passed or been confirmed to be operational. The following tests will not obtain favorable results unless all of this work has been performed.

NOTE. These tests only apply to blue water moving vessel deployments using *VmDas*. See the *VmDas* User's Guide for instructions on how to use this program.

The reason for Sea Acceptance Testing is that although the Dock Side Tests confirm the WorkHorse is operational, they do not confirm that the system is able to perform to its specifications. The performance of any ADCP relies greatly upon the installation into any platform. Therefore, the system must be tested at sea to understand the effects of the platform on the ADCP performance.

At Sea Testing includes tests for Acoustic Interference, Profiling Range, and Profiling Reasonableness testing. For each of these tests the following Equipment and ADCP setup requirements are recommended.

Equipment Required

- WorkHorse 300 kHz, 600 kHz, or 1200 kHz ADCP with firmware 16.xx or greater
- Computer

- *VmDas* Program
- *WinADCP* Program
- Navigation Interface Connected
- Heading Interface Connected

VmDas Setup

a. Start *VmDas*. On the **File** menu, click **Collect Data**. On the **Options** menu, click **Load**. Select the Default.ini file and click **Open**.

b. On the **Options** menu, click **Edit Data Options**. Click the **ADCP Setup** tab. Set the **Ensemble Time** to the **Ping as fast as possible**.

c. Select the **Use Command File** box. Use Table 18 to choose a command file for your ADCP, and load it into *VmDas* using the **Browse** button.

Table 18: Command Files

File Name	Description
WH300DEF.txt	Default setup for a WH 300 kHz ADCP to provide the most range with the optimal precision.
WH600DEF.txt	Default setup for a WH 600 kHz ADCP to provide the most range with the optimal precision.
WH1200DEF.txt	Default setup for a WH 1200 kHz ADCP to provide the most range with the optimal precision.

d. On the **Options** menu, click **Edit Data Options**. Click the **Averaging** tab. Set the **Short Term Average** to 300 seconds (5 minutes). Set the **Long Term Average** to 600 seconds (10 minutes).

4.5.1 Interference Test

The WorkHorse transmits and receives acoustic signals from the water. If other sonar devices are operating on the platform at the same time as the ADCP it is possible for those signals to bias the ADCP data. Therefore, all ADCPs must be tested to ensure that they are not receiving interference from other sonar equipment on board the vessel.

The following Interference Test will determine if there is interference from other devices on board the vessel.

Interference Test Platform Test Setup

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 19: Interference Test Minimum Water Depth Requirement

300 kHz ADCP	600 kHz ADCP	1200 kHz ADCP
400 meters	150 meters	60 meters

The platform speed for this test is drifting. The motors may be running if required for platform safety. The test sequence starts with ALL sonar and non-essential electronic equipment turned off. Only the ADCP should be on for the first test. This test establishes a base line for the interference and is critical to the rest of the tests. After a 10-minute period the first sonar device is turned on, transmission started, and the data is reviewed for interference terms. At the end of this 10-minute period the first sonar device is turned off and than the next sonar device is turned on and started pinging for 10 minutes. This process repeats for each of the sonar devices.

Interference Test Computer Screen Display Setup

View the RAW data (*.ENR files) being collected by the *VmDas* program in the *WinADCP* program contour plots for echo intensity data. This data will show the single ping return levels.

How to Identify Interference

If there is an interference term, the echo intensity data will show spurious echo intensity jobs. An example of what an interference term may look like what is shown in Figure 43, page 108.

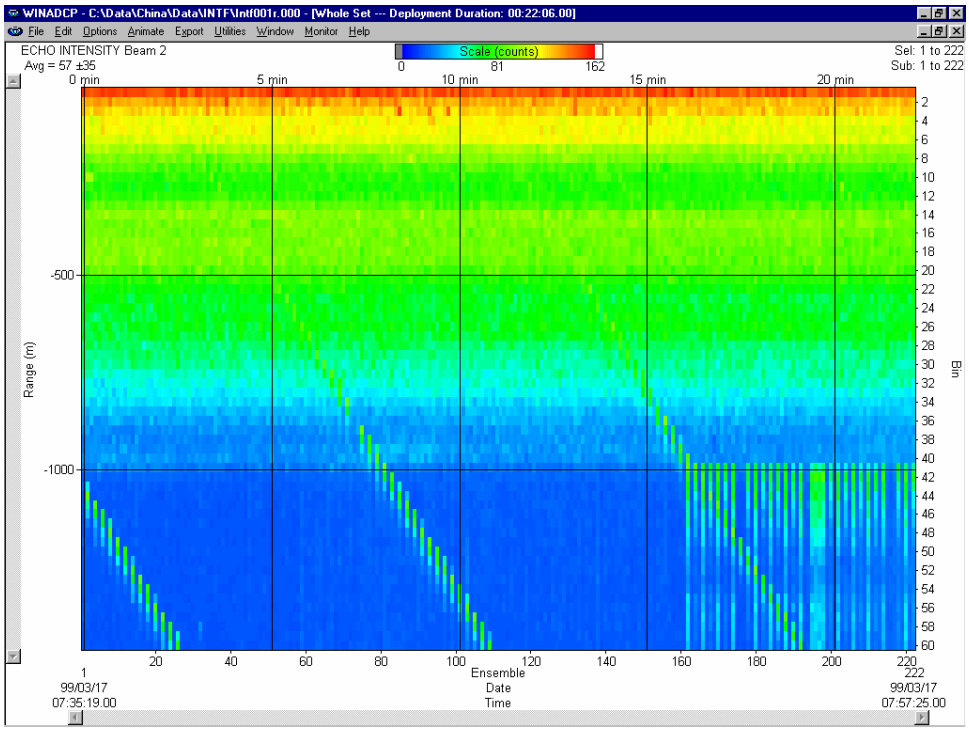

Figure 43. Interference Test

The interference term appears as the periodic green blocks in the data set. The interference is some what lost in the upper part of the profile however it can be seen clearly seen once the system reaches the noise floor (the point where signals are no longer being returned from the water).

NOTE. Interference terms such as above seen anywhere in the echo intensity profile data will result in a bias to the ADCP data.

4.5.2 Water Profile Range Test

The range of any ADCP is directly dependent on the level of backscattering material in the water, the transmit power into the water, the received sensitivity, and the level of the background noise. Each of these effects the range of the system in different ways, but in the end can result in reduced or extended range as follows.

- The ADCPs transmit power and receive sensitivity are fixed based on the transducer frequency. However, these may be affected by installation of an acoustic window in front of the transducer. A window will absorb both sound transmitted by the ADCP and the sound returned from backscatter in the water.
- The volume of the backscatter in the water will affect the range. All specifications for range assume that there is a certain amount

of backscatter in the water. The backscatter volume is not controllable in any way.

- The background noise changes as the platform's speed increases or decreases. There are two types of noise created by the moving platform; first, there is the noise due to propeller and engines; and second, there is the noise created by the rushing water across the platform and ADCP transducer.

This test is used to determine the effects of the background noise on the range of the ADCP. This information can be used to determine the optimum speed of the platform to obtain the desired range required.

Water Profile Range Platform Test Setup

This test requires that the platform be in water deeper than the ADCP's maximum expected profiling range. Use the following table to determine the minimum water depth required.

Table 20: Water Profile Range Test Minimum Water Depth

300 kHz	600 kHz	1200 kHz
250 meters	100 meters	40 meters

The platform course for this test is a continuous straight line. The speed of the platform will be varied during this test. At each speed, the system will be set to collect data for a minimum of 10 minutes. The following table lists the recommended speeds.

Table 21: Water Profile Range Test Platform Speed

Test #	Speed
Speed 1	Drifting
Speed 2	3 knots
Speed 3	6 knots
Speed 4	9 knots
Speed 5	12 knots
Speed 6	Maximum Speed

Water Profile Range Computer Screen Display Setup

View the Tabular Display of the Long Term Average data (10 minute averages) in the *VmDas* program.

How to Determine the Maximum Range of the ADCP

The data collected in the long-term average (10 minutes) tabular display will be used to determine the maximum range of the ADCP. The maximum profiling range of the system is determined by locating the last valid bin and then using that ping to determine the range. To determine the last valid bin the following criterion is used:

- The last bin must be above the bottom side lobe area
- The bin must have a percent good value above 25%
- The correlation value for at least 3 beams must be above the threshold of 120 counts

Locate the last valid bin for each of the speeds and fill in the table below.

Platform Speed	Last Valid Bin Number	Range to Last Bin	Average RSSI Value at Last Bin

Notes:

- Platform Speed must be input as a measurement from the Bottom Track (if in range) or the GPS speed.
- Range to Last Bin is calculated as follows: ((bin size) * (last bin number)) + (NF command)
- Average RSSI Value at Last Bin is the average of the 4 beams RSSI values in the last bin number

The results from the above test should be compared to the specified nominal range of the system. Assuming that there are sufficient scatterers in the water, the acoustic window is not attenuating the signal, and that that the platform background noise is variable there should be a speed at which the nominal range of the system is obtained.

4.5.3 Ringing Test

The ADCP transmits an acoustic pulse into the water. The main lobe of this pulse bounces off particles in the water and the signals returned from these particles are used to calculate the velocity of the water. The main lobe of the transmitted pulse is what we are using to process and calculate a velocity. The transmitted pulse, however, is made up of many side lobes off the main lobe. These side lobes will come in contact with metal of the transducer beam itself and other items in the water.

The energy from the side lobes will excite the metal of the transducer and anything bolted to the transducer. This causes the transducer and anything attached to it to resonate at the system's transmit frequency. We refer to this as "ringing." If the ADCP is in its receive mode while the transducer is ringing then it will receive both the return signals from the water and the "ringing." Both of these signals are then processed by the ADCP. The ringing causes bias to the velocity data.

All ADCPs "ring" for some amount of time. Therefore, each ADCP requires a blanking period (time of no data processing) to keep from processing the ringing energy. Each ADCP frequency has a different typical ringing duration. A blanking period (time of not processing data) is required at the beginning of each profile. The blanking distances required for the typical ringing period for each WorkHorse frequency is shown in the following table.

Table 22: Required Blanking Distance

Frequency	Typical Blank Period for Ringing
300kHz	2 meters
600kHz	1 meters
1200kHz	0.5 meters

Ringing will bias the velocity estimation to a lower value than it should be. However, when the platform motion is removed from the water profile data it will appear as a large velocity, which is the opposite of what it is really doing. This effect is caused because the vessel motion portion of the water profile data has been biased low.

Ringing Test Platform Test Setup

The key to success on this test is that the water velocity and direction not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 23: Ringing Test Water Depth Requirement

300kHz ADCP	600kHz ADCP	1200kHz ADCP
100-200 meters	50-100 meters	10-20 meters

Platform speed should be held to as fast a speed as possible without loosing any bottom tracking data for a period of 30 minutes. Typically, this will be a speed of 6-9 knots. Some experimentation may be required to find the maximum bottom track speed for the given depths above.

Ringing Test Computer Screen Display Setup

The Magnitude and Direction Profile Display of the Long Term Average data (10 minute averages) will be viewed in the *VmDas* program.

How to Determine the Ringing Test Results

Viewing the Long Term average of the magnitude and direction profile data, look for unreasonable shears from bin 1 to bin 2 to bin 3 and so on. If an unreasonable shear is seen, this is most likely ringing and your blanking needs to be increased by the following formula:

(bin size) * (last bin number with ringing) * 0.80

*The total blanking period is typical blanking period plus the increased blanking period required. The above value should be used to change both the NF and WF commands in all configuration files for this ADCP.

4.5.4 Water Profile Reasonableness Test

The mounting alignment of the WorkHorse transducer to the relative position of the heading input from the vessel is critical in the velocity estimates made by the ADCP. If either of these are not known and corrected for, it will result in both directional and velocity estimate errors in the water velocity data.

It is possible to confirm if the transducer alignment is correct by collecting data over the same water in several different directions. If the transducer is properly aligned, then both the magnitude and direction of the currents will appear the same in all directions that the platform travels.

Water Profile Reasonableness Platform Test Setup

The key to success on this test is that the water velocity and direction not change over the entire test period of 120 minutes. This may be difficult to adhere to in regions with large tidal effects. The test requires that the platform be within the ADCP bottom tracking range so that valid bottom track can be used. Use the following table to determine the optimum water depth range required.

Table 24: Water Profile Reasonableness Water Depth Requirement

300 kHz	600 kHz	1200 kHz
100-200 meters	50-90 meters	10-40 meters

Platform speed is held at a constant 5 knots during the entire course. The course for this test contains 4 legs. Each leg must be approximately 4500 meters (except for leg 2 which will be one half the length of each of the other legs). The course will appear as shown in Figure 44. The actual starting direction is not critical as long as the course completes the pattern shown in Figure 44.

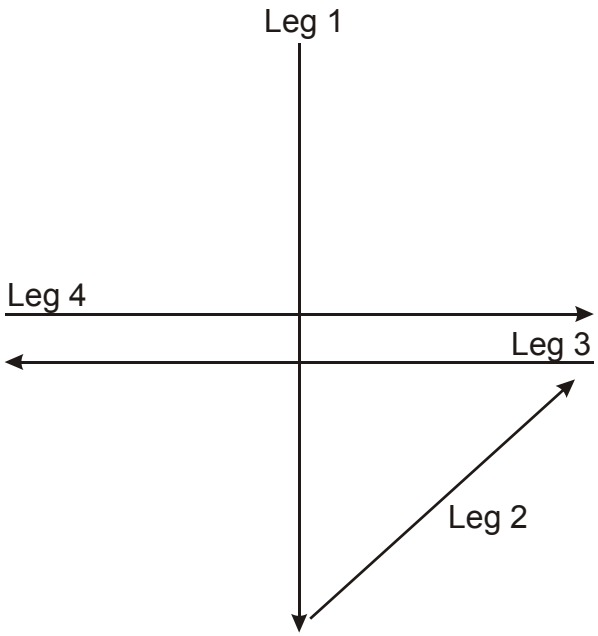

Figure 44. Water Profile Reasonableness Course

Water Profile Reasonableness Display Setup

View the *VmDas* Ship Track display of bin 3 with the bottom track reference. The Short Term Average (5 minute averages) data should be viewed.

How to Determine Water Profile Reasonableness

A pass condition is if the velocities in each of the ship track plotted directions has reasonably the same magnitude and direction. It is common to see some wild velocity magnitude and directions during turns. This happens as a result of the effects of the turn on the gyro heading device or the latency of the heading updates for a GPS heading input.

If the direction of the currents is not the same in each of the four directions, then it will be necessary to enter in a transducer misalignment angle.

Changing the transducer alignment angle and playing back the same data file again allows you to determine the misalignment angle. The best way to perform this check out is to use incremental change of 5-10 degrees at a time.

Assuming that the misalignment angle was not required or could be determined, it is now possible to use the same data just collected to determine how reasonable the navigation data input is. Change the data display reference from bottom track to the navigation data in the *VmDas* program. There should be little to no change in the velocity magnitude and direction if the navigation data is a valid input for a reference.

4.5.5 Bottom Tracking Test

The bottom tracking capability of the ADCP varies depending on the type of bottom (hard, soft, rock, sand, etc.), the slope of the bottom, and the speed of the vessel (background noise).

Before testing the Bottom Track capabilities, the Water Profiling Range Test must be performed. Through the results of this test, determine the platform speed in which the range to the last valid bin obtained the specified nominal range of the ADCP frequency being used.

If it was not possible to reach the specified nominal range during the Water Profiling Range test, then determine the speed at which it allowed the best range possible. Calculate the percentage of the nominal range that was obtained by the system.

Bottom Tracking Platform Test Setup

The key to this test is to operate the system in an area where both the minimum and maximum bottom tracking range can be obtained. The platform will travel over water that is very shallow (<10 meters) to very deep (greater than the maximum bottom track range). It does not matter if the water starts deep and goes shallow or vice-versa.

The course of the platform should be a relatively straight line. The platform speed should be no greater than the velocity recorded in the Water Profiling Range Test.

Bottom Tracking Computer Screen Display Setup

View the raw data display of the *VmDas* bottom track display window.

How to Determine Bottom Tracking Reasonableness

Viewing the bottom track velocity data, record the maximum and minimum average of the bottom track depths in the table below.

Beam Number	Minimum Depth (meters)	Maximum Depth (meters)

Beam Number	Minimum Depth (meters)	Maximum Depth (meters)
Beam 1		
Beam 2		
Beam 3		
Beam 4		

A pass condition is if the maximum depth of the system is equal to the specification for the nominal bottom track range.

NOTE. If the system was not able to water profile to the nominal range, then the bottom track range should be reduced to no more than the same percentage as the water profile loss.

If the Bottom Track **did** obtain the complete range and the Water Profile **did not**, then it is likely that there is insufficient backscatter in the water to obtain the specified range.

5 Troubleshooting

Considering the complexity of the WorkHorse, we have provided as much information as practical for field repair; *fault location to the component level is beyond the scope of these instructions*. The provided information assumes that faults are isolated with a large degree of certainty to a Least Replaceable Assembly (LRA) level only. The time to repair the system will be minimized if an entire replacement unit is available in the field. If time to repair is of essence, Teledyne RD Instruments strongly advises the availability of the listed LRAs.

NOTE. When an addition or correction to the manual is needed, an Interim Change Notice (ICN) will be posted to our web site on the Customer Care page (www.rdinstruments.com). Please check our web site often.

Table 25: List of Least Replaceable Assemblies

LRA	Description
ADCP	The entire ADCP; includes the electronics, housing, transducer ceramic assemblies, and end-cap.
Deck Box (Mariner only)	The Deck Box contains all electronics necessary to supply power, provide user communication and gyro interface.
I/O Cable	Connects the ADCP with the Deck Box (Mariner) or Computer.
Serial Cable	Connects the Mariner Deck Box to the computer.
End-Cap	Includes the end-cap, connector, and internal I/O cable.
ADCP electronics	The spare boards kit Includes the PIO, CPU, and DSP boards.
PC Card	Replaceable PC recorder card.

Since these Least Replaceable Assemblies are manufactured in different configurations, please contact Teledyne RD Instruments (see "Technical Support," page 134 for contact information) to obtain the correct part number for your specific system configuration. When contacting Teledyne RD Instruments about a replacement assembly, please provide the serial numbers of the ADCP and Deck Box. If you want to replace the I/O Cable only, then please provide the cable length.

5.1 Equipment Required

Special test equipment is not needed for trouble shooting and fault isolation. The required equipment is listed in Table 26, page 117. Any equipment satisfying the critical specification listed may be used.

Table 26: Required Test Equipment

Required Test Equipment	Critical Specification
DMM	Resolution: 3 ½ digit
	DC-Voltage Range: 200 mV, 2V, 20 V, 200V
	DC-Voltage Accuracy: ± 1%
	AC-Voltage Range: 200 V, 450 V
	AC-Voltage Accuracy: ± 2%
	Resistance Range: 200, 2 k, 20 k, 200 k, 20 MOhm
	Res.-Accuracy: ± 2% @ 200 Ohm to 200 kOhm
	Res.-Accuracy: ± 5% @ 20 Mohm
	Capacitance Range: 20 nF, 2 uF, 20 uF
	Capacitance Accuracy: ± 5%
Serial Data EIA Break-Out Box such as from International Data Sciences, Inc. 475 Jefferson Boulevard Warwick, RI 02886-1317 USA.	Model 60 or similar is recommended as it eases the troubleshooting of RS-232 communication problems significantly. Other manufacturers or models may be substituted.

NOTE. The EIA Break-out Panel is not necessary, but eases RS-232 communication problems troubleshooting significantly.

5.2 Basic Steps in Troubleshooting

The first step in troubleshooting is determining what type of failure is occurring. There are four types of failures:

- Communication failure
- Built-In test failure
- Beam failure
- Sensor failure

Communication failures can be the hardest problem to solve as the problem can be in any part of the system (i.e. the computer, WorkHorse, cable, or power). The symptoms include having the system not respond, or not responding in a recognizable manner (for example "garbled" text).

Built-In test failures will appear when the system diagnostics are run. Use *WinSC* or *BBTalk* to identify the failing test.

Beam failures can be identified when collecting data or during the user-interactive performance tests.

Sensor failures can also be identified when collecting data or during the user-interactive performance tests. The sensor may send incorrect data, or not be identified by the system.

5.3 Troubleshooting the WorkHorse

Although the WorkHorse is designed for maximum reliability, it is possible for a fault to occur. This section explains how to troubleshoot and fault isolate problems to the Least Replaceable Assembly level (see Table 25, page 116). Before troubleshooting, review the procedures, figures, and tables in this guide. Also, read the "System Overview," page 7 to understand how the WorkHorse processes data.

CAUTION. Under all circumstances, follow the safety rules listed in the "Troubleshooting Safety," page 118.

5.3.1 Troubleshooting Safety

Follow all safety rules while troubleshooting.

CAUTION. Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so.

CAUTION. Complete the ground path. **The power cord and the outlet used must have functional grounds.** Before power is supplied to the WorkHorse, the protective earth terminal of the instrument must be connected to the protective conductor of the power cord. The power plug must only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

CAUTION. Any interruption of the earthing (grounding) conductor, inside or outside the instrument, or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

CAUTION. Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

CAUTION. Do not install substitute parts or perform any unauthorized modifications to the instrument.

CAUTION. Measurements described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

CAUTION. Do not attempt to open or service the power supply.

CAUTION. Any maintenance and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

CAUTION. Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

5.4 Troubleshooting a Communication Failure

WorkHorse ADCPs communicate by means of two serial communication channels. The user can choose between RS-232 and RS-422 classes of serial interfaces with a switch on the PIO board in the ADCP.

To successfully communicate, both the host computer and the ADCP must communicate using the same class of serial interface. Standard serial interfaces in IBM compatible computers are also RS-232.

NOTE. If you have just received your WorkHorse from TRDI, the standard configuration is RS-232 for Sentinels and RS-422 for Monitors and Mariners.

NOTE. If you are using a high baud rate and/or a long I/O cable (greater then 50 meters) connected to a Sentinel ADCP, RS-232 may not work. Switch to RS-422 and try to wakeup the WorkHorse again.

NOTE. Most communication problems are associated with incorrect cabling (i.e. the serial cable is connected to the wrong port) or data protocols (i.e. the wrong baud rate is set between the H-ADCP and computer).

Incorrect Wakeup Message

When you send a break and the wakeup message is not readable (garbled) may indicate a communications mismatch or lost boot code.

- Sending a break causes “garbage” to appear on the screen. The “garbage” text may keep scrolling. This happens when the computer is using RS-232 and the ADCP is set for RS-422 or vice-versa. Check the RS-232/RS-422 switch on the PIO board (see “Communications Setting,” page 64).
- Sending a break causes “garbage” to appear on the screen. You can hear the ADCP “beep” when the break is sent. The “garbage” text does not keep scrolling. Check that the ADCP and computer are

both using the same baud rate. See the CB-command in the WorkHorse Command and Output Data Format guide.

- If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and an "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

No Wakeup Message

When you send a Break and do not see the wakeup message, you need to isolate the problem to a computer fault, power, cable failure, or an ADCP problem. Check the following items:

a. Connect the ADCP to a computer as shown in the ADCP's User's Guide. Check that all cable connections are tight.

b. Is the ADCP AC power adapter working? Is the input voltage to the AC power adapter between 100 to 240 VAC? Is the output level 48 VDC?

c. If the ADCP is running from a battery, check that the battery voltage is above 30 VDC. ADCPs will work at 20 VDC with at least 400 milli amps; however, both lithium and alkaline battery packs with voltages below 30 VDC are at or near their end of life, and are approaching uselessness.

d. Is the computer hooked up properly? Does it have power?

e. Make sure that your computer and the *BBTalk* programs are set up to use the communication port the serial cable is connected to on the computer.

5.4.1 Check the Power

The following test can be done with a voltmeter to check the power.

Monitor/Mariner/Sentinel ADCPs

Check the power going into the ADCP by measuring the voltage on the end of the cable that connects to the WorkHorse at Pins 3 and 7 (GND) (see "Workhorse Cables," page 135). The voltage should be +48 VDC (using the standard AC adapter) or +48 VDC if you are using the Deck Box. If not, check the voltage at the other end of the cable, the AC adapter, and Deck Box (Mariner only).

5.4.2 Check the I/O Cable

This test will check the communication between the computer and Monitor or Sentinel WorkHorse.

a. Disconnect both ends of the cable and measure the continuity using a DMM (see "Workhorse Cables," page 135 for the wiring diagram). Correct any problems found.

a. Reconnect the I/O cable to host computer.

a. Load *BBTalk* on your computer. Select the proper communications port (see the RDI Tools User's Guide for help on using *BBTalk*).

b. For RS-232 communications, short pins 1 and 2 together on the female 7-pin connector that was plugged into the WorkHorse (see "Workhorse Cables," page 135). If you are using RS-422, connect a jumper between pin 2 to pin 6 and another jumper between pins 1 to pin 5 of the underwater connector at the WorkHorse end of the cable.

c. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see characters, but not correctly (garbage), the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper on pins 1 and 2 and then push any keys on the keyboard. You should NOT see anything you type.

d. If the keys are echoed correctly on the screen, the computer and the communication cable are good. Re-connect the I/O cable to the WorkHorse. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in "Workhorse Cables," page 135.

NOTE. A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

5.4.3 Check the Mariner Cables

This test will check the serial communication cable between the computer and Deck Box (Mariner only).

a. Disconnect both ends of the cable and measure the continuity using a DMM (see "Workhorse Cables," page 135 for the wiring diagram). Correct any problems found.

b. Reconnect the serial cable to host computer. Start the Teledyne RD Instruments software utility program *BBTalk* on your computer. Make sure to select the proper communications port.

c. For testing a RS-232 cable, jumper pins 2 and 3 at the far end of the cable. To check a RS-422 cable, connect one jumper between pin 2 to 4, and one jumper between pins 7 to 8.

d. Type any characters on the keyboard. The keys you type should be echoed on the screen. If you see some characters, but not correctly, the cable may be too long for the baud rate. Try a lower baud rate. If this works disconnect the jumper and then push any keys on the keyboard. You should NOT see anything you type.

e. If you use cables that are **not** supplied by Teledyne RD Instruments you must make sure that transmit and receive pairs are not interchanged. The above loop-back test does not show if transmit and receive pairs are interchanged. Thus, it is important that you check the wiring diagrams provided in "Workhorse Cables," page 135.

NOTE. A loop-back test does not show if transmit and receive wires or pairs are interchanged, even though characters may be displayed correctly.

f. If the keys are echoed correctly on the screen, the computer and the communication cable are most likely good. Re-connect the serial cable to the Deck Box. If the WorkHorse still does not wakeup, there could still be a problem with the Deck Box or ADCP.

5.4.4 ADCP Checks

Once you have eliminated possible problems with the power, I/O cable, communications settings, and the computer, that leaves the ADCP as the source of the problem. The following checks may help in some situations.

Cold Start the ADCP

a. Remove the housing to gain access to the PC boards.

b. Remove *all* power to the ADCP.

CAUTION. Disconnect the power cables P1 and P2 on the PIO board to ensure that NO POWER is applied to the ADCP during the next step.

c. Short TP10 to TP11 on the PIO board for 10 seconds.

d. Remove the jumper.

e. Connect the computer and connect power to the ADCP. Send a break to the ADCP. This should start the ADCP in the "cold start" mode.

Fuse

Check the fuse on the PIO board is not blown (see "Fuse Replacement," page 62 for fuse replacement procedures).

CAUTION. Only fuses with the required rated current, voltage, and specified type must be used. Do not repair fuses or short circuit fuse-holders. To do so could cause a shock or fire hazard.

Boot Code Error

If the ADCP gives a steady "beep" when power is applied, the ">" prompt appears on the screen, and a "X" appears when additional breaks are sent, this may indicate that the boot code has been lost. This can happen if you abort while downloading new firmware. Try downloading the firmware again.

5.4.1 Mariner Deck Box Checks

Once you have eliminated possible problems with the WorkHorse power, the serial data communication cable, and the host computer, that may leave the Deck Box as the source of the problem. Check the following conditions.

CAUTION. The Deck Box contains Electro Static Sensitive Devices. You must take accepted ESD prevention measures **before** opening the Deck Box.

a. One of the interconnecting cables inside the Deck Box may not be fully seated. Turn off power. Remove the top cover of the Deck Box and check that all of the cables are properly seated.

b. Check the Deck Box fuses are not blown (see "Fuse Replacement," page 62 for fuse replacement procedures).

c. Verify that the **Power Status** LED indicator located at the front panel next to the circuit breaker switch is lit. Make sure power to the Deck Box is connected and that the circuit breaker is in the ON position.

d. Verify that if you send push the Reset button, the **Channel 1 In** LED on the front panel lights up temporarily. If it does, that means that the serial data receive channel seems to be functioning. If it does not light up then the receive channel is not functioning.

e. If the **Channel 1 In** LED indicator on the front panel does light up while pushing **Reset**, verify that the **Channel 1 Out** LED next to it responses by lighting up temporarily as well. If the **Channel 1 Out** LED does light up, but there is no Wake-Up message displayed on the computer screen, then this indicates there is still a problem with the serial data transmit path. A serial data Break-Out box between the Deck Box and the serial communications cable would be helpful for narrowing down the problem.

f. If the Break-Out box does not indicate any data transmission from the Deck Box to the computer but the **Channel 1 Out** LED front panel indi-

cator does, the problem most likely is with the Deck Box. Switch power to the Deck Box off, and after a few seconds on again. Repeat the Deck Box Checks from the beginning. If the system does not respond normally, it may be malfunctioning and you should contact Teledyne RD Instruments.

g. If the Break-Out box does indicate data transmission but there are no characters displayed on the computer screen, then the problem still lies with the communications cable or the computer.

5.5 Troubleshooting a Built-In Test Failure

The built-in diagnostic tests check the major ADCP modules and signal paths. The spare boards kit may be used to repair some failures. This kit includes:

- Spare Boards including PIO board, CPU board, and DSP board. These boards are held together with the standard M4 screw assembly and kept inside a protective anti-static bag.
- A disk containing your original beam cosine matrix table
- Tools for installation

NOTE. The Spare Boards kit is not included with the system. You can order the kit by contacting Teledyne RD Instruments Customer Service department (see “Technical Support,” page 134).

5.5.1 When to use the Spare Boards Kit

Use this Kit whenever you have any of the following problems:

- Cannot communicate to the WorkHorse and you have ensured that the serial port on the computer, WorkHorse Cable, Deck Box (Mariner only), and WorkHorse RS-232 to RS-422 converter (if applicable) are all working properly.
- Your WorkHorse fails any of the following PA tests at any time:

  CPU Tests:
  - RTC
  - RAM
  - ROM

  DSP Tests:
  - Timing RAM
  - Demod RAM
  - Demod REG
  - FIFOs

  System Tests:
  - XILINK Interrupts
  - Receive Loop Back Test

- Your WorkHorse fails any of the following PA tests provided the items indicated by {} have been checked:

  Recorder Tests:

  Any recorder tests fails {provided that the PCMCIA card(s) have been checked for proper installation, operation and they are DOS formatted; we STRONGLY recommend checking PCMCIA cards in a computer before replacing the boards}

  System Tests:

  Transmit {if the WorkHorse fails when it is in water and air bubbles have been rubbed from the faces}

  Sensor Tests:

  H/W Operation {if the WorkHorse fails when it is NOT sitting/resting on its side, or located near a large magnetic field like a motor in a boat}

The spare boards kit will not correct any of the following failures:

- A damaged beam or its urethane surface
- Damage to the transducer beam connections below the copper shield
- If it passes all PA tests and yet the data is all marked as bad
- Fails the following PA test:

  System Tests:
  Wide Bandwidth {bandwidth tests may fail due to external interference}

  Narrow Bandwidth {bandwidth tests may fail due to external interference}

  RSSI Filter

  Transmit

Table 27: Pre-deployment Test (PA) Possible Cause of Failures

PA Test Name	Possible Cause of Failure
Pre-Deployment Tests CPU Tests: RTC RAM ROM	CPU board failed
Recorder Tests: PC Card #0 Card Detect Communication DOS Structure Sector Test (short) PC Card #1 Card Detect Communication DOS Structure Sector Test (short)	PC card not plugged in PC card failed DSP board failed
DSP Tests: Timing RAM Demod RAM Demod REG FIFOs	DSP board failed
System Tests: XILINX Interrupts	DSP or CPU board failed
Receive Loop-Back	DSP or CPU board failed
Wide Bandwidth	Not in water External interference DSP or Receiver board failed
Narrow Bandwidth	
RSSI Filter	
Transmit	Not in water or PIO board failed
Sensor Tests: H/W Operation	PIO board failed Receiver board failed Pressure sensor failed ADCP laying on its' side

5.5.2 Installation of the Spare Board Kit

This Kit has been setup so that you will replace all three of the Workhorse boards at once. This is done so that you do not have to risk damaging the individual boards while swapping in individual boards. The heading, pitch, and roll sensors have all been calibrated (the temperature sensor is an independent calibration and not changed by these new boards). Once you have replaced your original boards place them back in the Spare Board Kit box and contact Teledyne RD Instruments Customer Service Department so that you can return them for repair.

CAUTION. Before handling either the Spare Board Kit or the original Board Set, always wear an earth-grounding static protection strap. The electronics in the Workhorse are very sensitive to static discharge. Static discharge can cause damage that will not be seen immediately and will result in early failure of electronic components.

We assume that a qualified technician or equivalent will perform all of the following work.

The Spare Boards Set will allow your system to perform to the same velocity specifications as your original set. There is, however, an offset error in the compass that can be as great as ±1.5 degrees. This error CANNOT be removed by doing the Field Calibration procedure (AF command) even though you MUST do this as part of the installation. The additional ±1.5 degrees can only be removed by TRDI at the factory.

However, in most cases, the total compass error will still be within our original specification of ±5.0 degrees. The only way to be sure that you have smaller errors than this specification is to perform your own local compass verification and correct any errors you find during your post processing of the data.

5.5.3 Remove the Original Set of Boards

a. Remove the Transducer assembly from the pressure case. Use "WorkHorse Disassembly," page 47 for instructions.

b. With your earth-ground static protection strap on, use a 3mm Allen wrench, to remove the four bolts that secure the three original Workhorse boards to the Transducer assembly.

c. Note the orientation of the transmit cable connector as it is plugged into the PIO board and to the Receiver board (see Figure 45, page 128).

   This cable must be removed and it has a very tight fit. To remove this cable, lift straight up on the three boards and tilt slightly (no more than 2 cm) toward the cable. This should allow you enough slack to unplug the cable from the PIO board. If this is not possible you may unplug the

cable from the Receiver board. Be sure to note its orientation before unplugging.

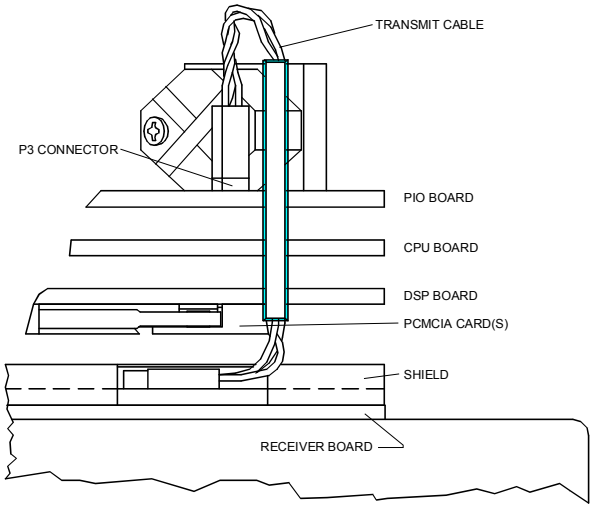

Figure 45. Transmit Cable

d. Once the transmit cable has been disconnected you may now remove the top three boards as a set by lifting the set straight up.

These top three boards are connected to each other via connectors and will remain as one piece (see Figure 46, page 129). The DSP board connects to the Receiver board through a 26-pin header. The 26-pin header is a series of male pins. The 26-pin header may or may not stay connected to the DSP board when you remove the top three boards. If you see that there are male pins sticking out of the DSP board when you finish removing the board set then the header has remained attached to the DSP board. If this happens remove it and place it into the Receiver board. To remove it, gently rock it back and forth while pulling it away from the DSP board. Once removed, align it with the connector on the Receiver board and press it into place.

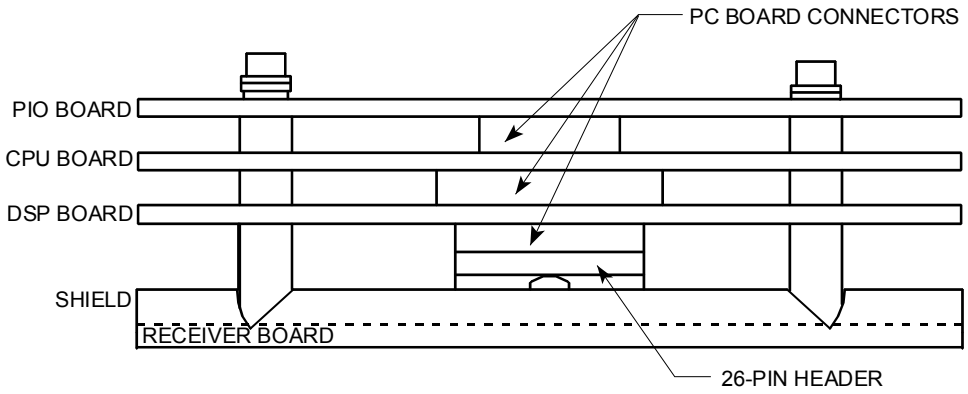

Figure 46. PC Board Connectors

e. Remove all PCMCIA card(s) from the original set of boards. These PCMCIA cards will be used again once you install your Spare Boards Set. The Spare Board set does NOT contain a PCMCIA card(s). The PCMCIA card(s) are located on the bottom of the DSP board. To remove the PCMCIA card(s) press the button(s) on the side of the PCMCIA card slot. As you press this button the PCMCIA card will slide out. You will have to pull the card(s) out the rest of the way once the button is depressed all the way in.

f. Set the original board set to the side for now.

5.5.4 Installing the Spare Board Kit

a. With your earth-ground static protection strap on, remove the Spare Board Kit from the anti-static bag.

b. Using a 3 mm Allen wrench and a 7mm wrench remove the nuts from the bolts that secure the Spare Boards together. You will be using these bolts to secure the spare set in your system. DO NOT change the position of any of the bolts. The bolt containing the felt washers and ground jumper must remain in the same position (see Figure 47, page 130).

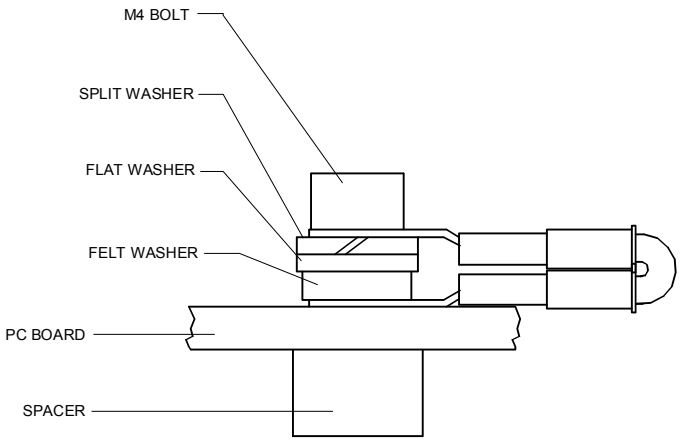

Figure 47. Ground Jumper

c. Place the nuts (just removed) on the four bolts of your original set of boards and place them into the anti-static bag. You will use the new set of bolts included in the Spare Board kit to secure them to the Transducer assembly.

d. Install all PCMCIA cards removed in "Remove the Original Set of Boards," page 127 step e into the PCMCIA card slots. The PCMCIA card is keyed and will only connect when it has been aligned correctly and slid all the way in. The PCMCIA card is installed with the label side pointing away from the DSP board.

e. Connect the Spare Board set to the Receiver board. Align the Spare Board set to the 26-pin header connected to the Receiver board. As you connect the Spare Board set, connect the transmit cable you removed in "Remove the Original Set of Boards," page 127 step c. Be sure to connect the cable in the same orientation as was installed on the original board set.

   To test that the transmit cable is connected properly, start *BBTalk* and run the PT4 test. The test failure example shown below is what you would see for a missing or improperly attached transmit cable.

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.21
Teledyne RD Instruments (c) 1996-2002
All Rights Reserved.
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

f. Insert the four new bolts and tighten to 4 Newton-meters.

g. Install the Transducer into the Pressure Case. See "Workhorse Reassembly," page 48 for instructions.

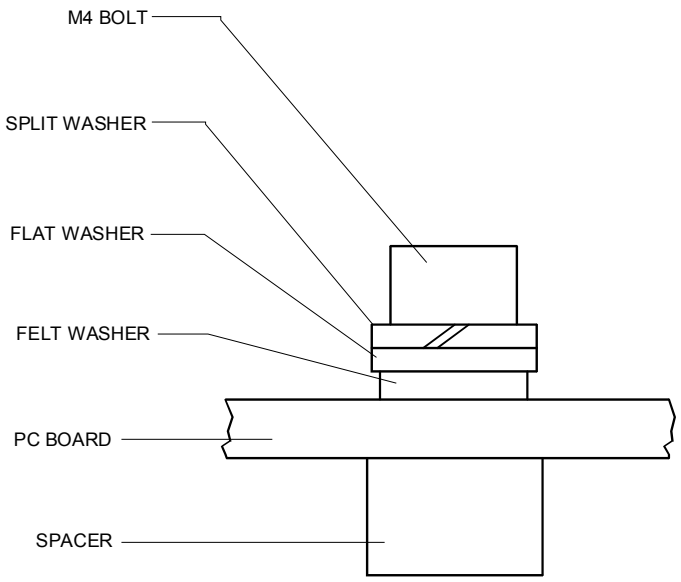

Figure 48. Mounting Hardware

5.5.5 Installing the Beam Cosine Matrix

The beam cosine matrix table corrects small transducer beam misalignment angles that occur during manufacturing.

a. Connect your Workhorse ADCP as you would normally and apply power.

b. Start *BBTalk* and confirm that the Workhorse ADCP is communicating normally and which communication port you are using (COM 1 or COM 2).

c. Place the Beam Cosine Matrix Disk into your computer's disk drive.

d. If your ADCP is connected to COM 1, press **<F2>** and run the script file *xxxx_1.scr* (where xxxx is your system serial number).

   If your ADCP is connected to COM 2, press **<F2>** and run the script file *xxxx_2.scr* (where xxxx is your system serial number).

   Your Beam Cosine Matrix table will automatically be updated in your ADCP and a file called SPRBD.LOG will be created. You can view the contents of this file to confirm that the data entered during the &V portion matches the contents in the PS3 results under the label Q14.

5.5.6 Testing the System

a. Install the Transducer in the Pressure Case.

b. Connect the cable and power as you normally do and test the ADCP as shown in "Testing the WorkHorse," page 95. All PA tests should pass when run in water and the PC tests should pass out of water.

c. ***Perform a field calibration of your compass*****.** Use "Compass Calibration," page 58 for instructions on running the AF command. Remember that there will be up to 1.5 degrees of offset error in the compass measurement. This error is not removed by the field calibration.

- You have completed the WorkHorse Spare Board Installation. The original boards can be returned to TRDI for repair. Please contact the Teledyne RD Instruments Customer Service Department for return shipping instructions and repair costs (see "Technical Support," page 134).

5.6 Troubleshooting a Beam Failure

If the beam continuity test fails, a bad DSP board, Receiver board, PIO board, or a bad beam may cause the failure. If replacing the DSP and PIO board (included with the spare boards kit) does not fix the problem, the ADCP must be returned to TRDI for repair.

```
>PC1

BEAM CONTINUITY TEST

When prompted to do so, vigorously rub the selected
beam's face.

If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  41  46  45  43  41  46  45  43  41  46  45  42  41  46  44  42

Rub Beam 1 = PASS |   NOTE - Possible cause of failure
Rub Beam 2 = PASS |          DSP Board
Rub Beam 3 = PASS |          Receiver Board
Rub Beam 4 = PASS |          PIO Board
>                 |          Beam
```

5.7 Troubleshooting a Sensor Failure

If the PA test fails the sensor test, run PC2 to isolate the problem. The ambient temperature sensor is mounted on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature sensor is located on the PIO board under the compass. The ADCP will use the attitude temperature if the ambient temperature sensor fails.

If one of the temperature sensors fails, the PC2 test will show both sensors at the same value.

```
>PC2
Press any key to quit sensor display ...

Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp   Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C         22.97°C         0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C         22.97°C         0.0 kPa
300.95°  -7.60°  -0.99°     Up          24.37°C         22.97°C         0.0 kPa
300.71°  -7.61°  -0.96°     Up          24.37°C         22.98°C         0.0 kPa
300.69°  -7.61°  -0.96°     Up          24.35°C         22.98°C         0.0 kPa
300.76°  -7.60°  -0.98°     Up          24.38°C         22.97°C         0.0 kPa
>
```

NOTE. If the temperature sensor is bad, the data can still be collected with no effects to accuracy or quality. Contact TRDI about scheduling a repair of the temperature sensor at your convenience.

NOTE. For external sensor verification, see “Dock Side Tests,” page 102.

5.7.1 Fault Log

To determine why a sensor failed, view the fault log. To view the fault log, start *BBTalk*. Press the **End** key to wakeup the Long Ranger. Type the following commands: **CR1**, **PA**, **FD**, **FC**. The fault log will be displayed by the FD command and is cleared by the FC command.

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version x.xx
Teledyne RD Instruments (c) 1996-1997
All rights reserved.
[BREAK Wakeup A]
>CR1
>PA
|          (PA test results (not shown))
|
>FD
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:   97/11/05,11:01:57.70
Time of last fault:    97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
```

```
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
>FC
```

5.8 Technical Support

Teledyne RD Instruments

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5.9 Workhorse Cables

This section has information on Workhorse cabling. Special user-requests may cause changes to the basic wiring system and may not be shown here. We provide these drawings only as a guide in troubleshooting the ADCP. If you feel there is a conflict, contact TRDI for specific information about your system. The following figures show various Workhorse cable locations, connectors, and pin-outs.

NOTE. Where shown, the color code is for reference only; your cable may be different.

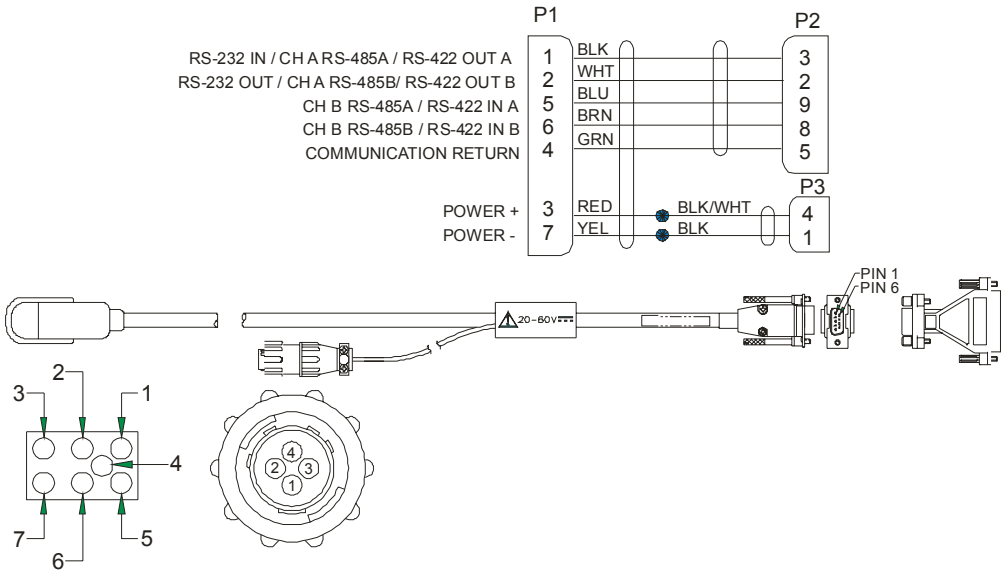


Figure 49. Monitor and Sentinel I/O Cable Wiring

NOTE. Where shown, IN refers to signals going into the ADCP and OUT refers to signals coming out of the ADCP.

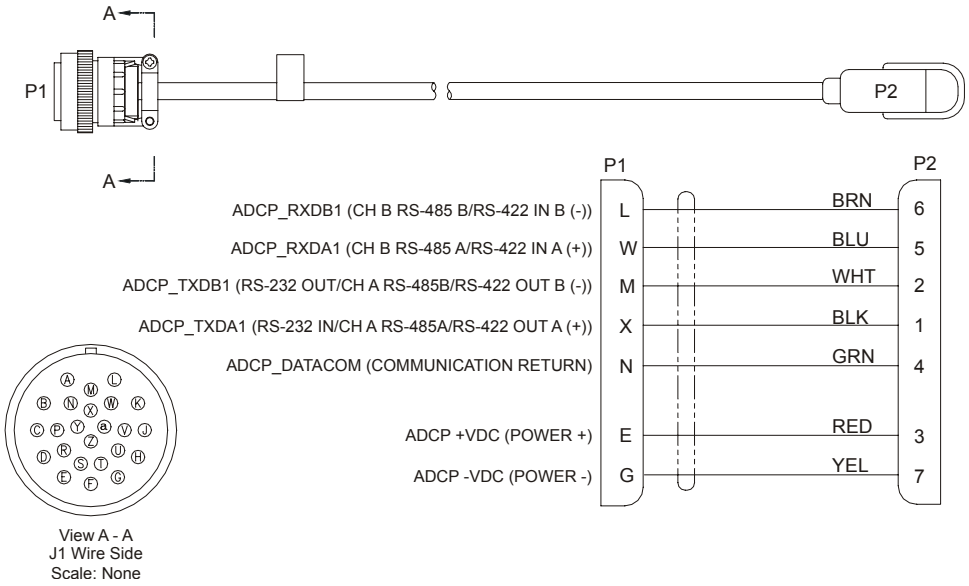
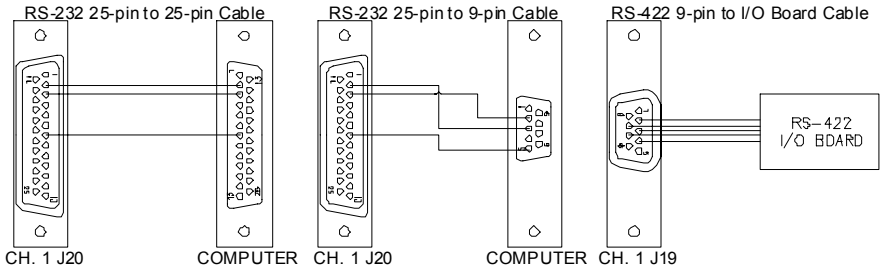


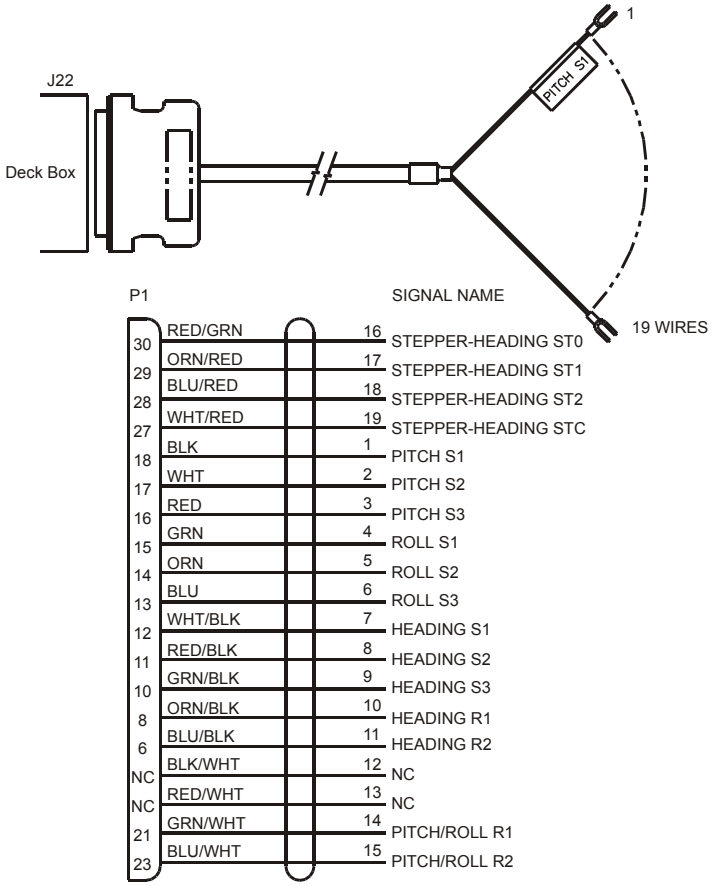
Figure 50. Mariner I/O Cable Wiring



Cable Type	ADCP Signal	Deck Box	Computer	Computer Signal
RS-232 25-pin to 25-pin	DATA IN DATA OUT GND	2 3 7	2 3 7	DATA OUT DATA IN GND
RS-232 25-pin to 9-pin	DATA IN DATA OUT GND	2 3 7	3 2 5	DATA OUT DATA IN GND
RS-422 9-pin to I/O board	DATA IN A DATA OUT A COMMON DATA IN B DATA OUT B	2 4 3 7 8	- - - - -	DATA OUT A (+) DATA IN A (+) COMMON DATA OUT B (-) DATA IN B (-)

NOTE: These cables provides RS-232 or RS-422 communications. Two cables are provided with the instrument: (1) 25-pin to 25-pin RS-232 cable, and (1) 25-pin to 9-pin RS-232 cable. Each cable is about 2-meters long and has a diameter of 8 mm (0.31 in.). For cable lengths longer than 25 meters, we recommend you use RS-422 communications. The cable for RS-422 communication is not provided with the equipment.

Figure 51. Mariner Deck Box to Computer Serial Cable



NOTE: This cable provides synchro/stepped heading signals and/or synchro tilt from an external gyrocompass to the deck box. This cable is provided with the instrument (length specified by user). Cable specifications: 26 conductors, cable OD = 8 mm (0.31 in.), terminated at one end with a 37-pin connector (deck box side), terminated at the other end (gyro side) with 19 spade (or forked) lugs for connecting to the gyro's terminal strip.

Figure 52. Mariner Gyro Cable

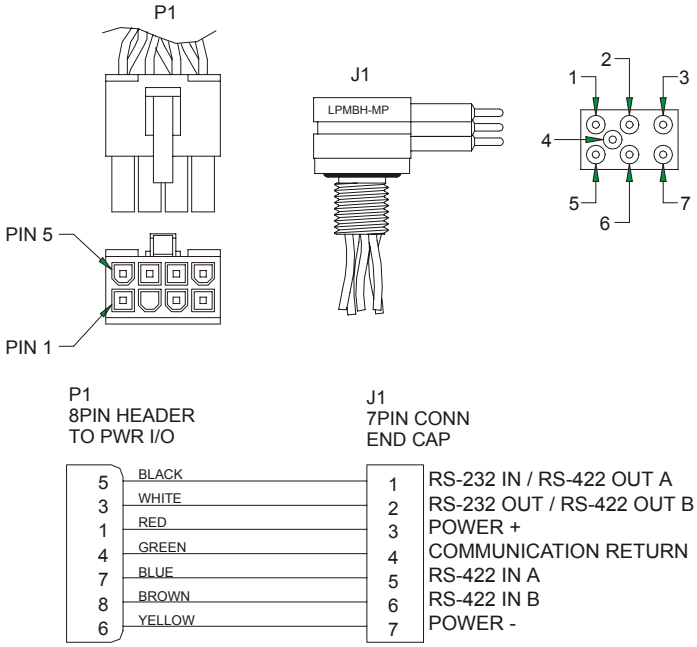


Figure 53. Mariner/Monitor/Sentinel Internal I/O Cable (End-Cap to PIO Board) Wiring

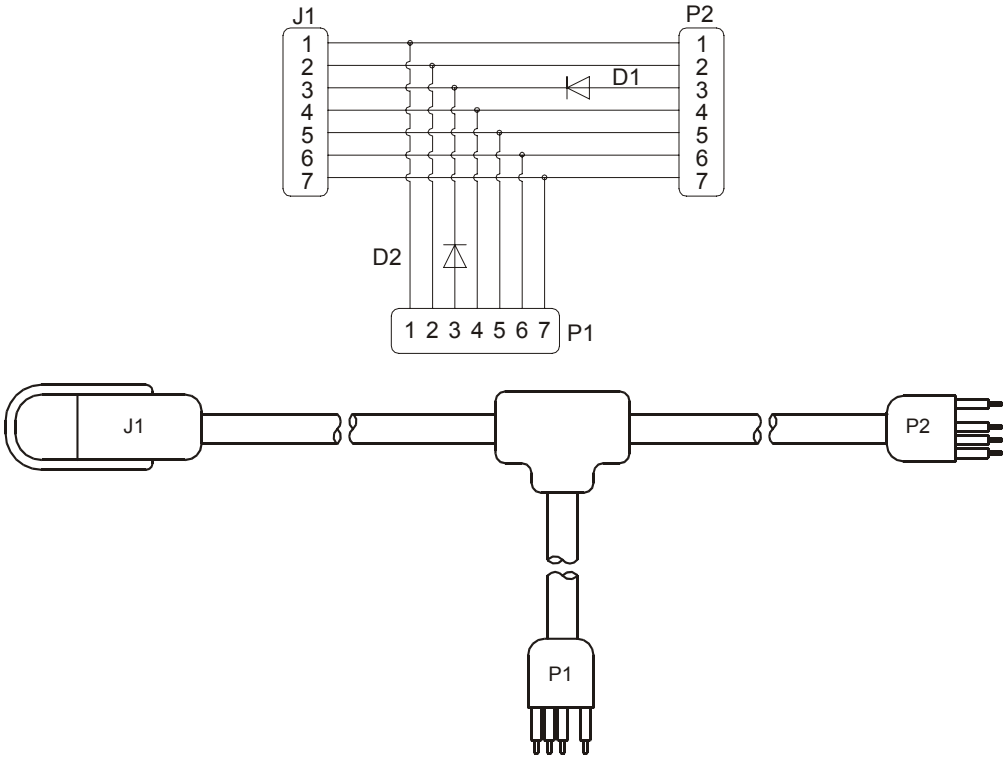


Figure 54. External Battery Pack “Y” Cable

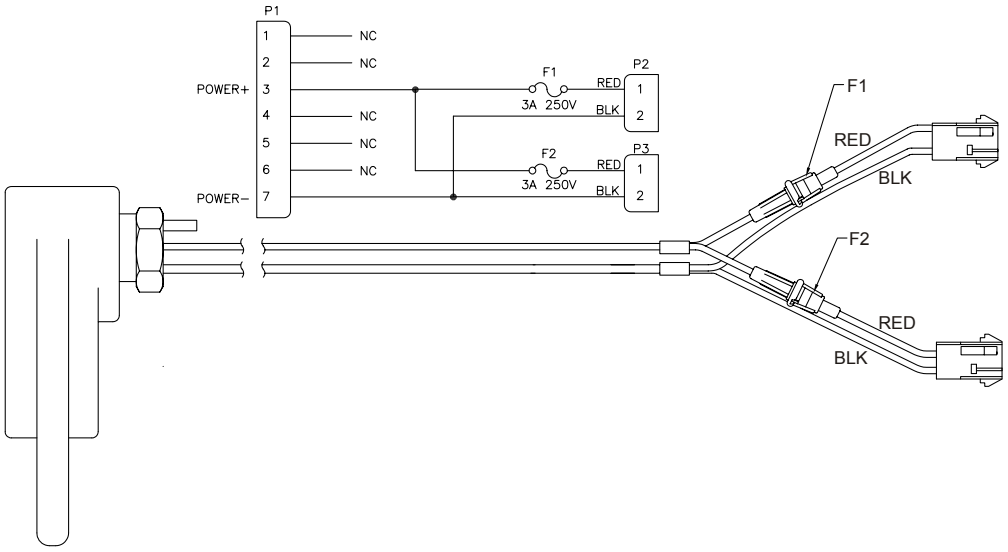


Figure 55. External Battery Case Internal Wiring

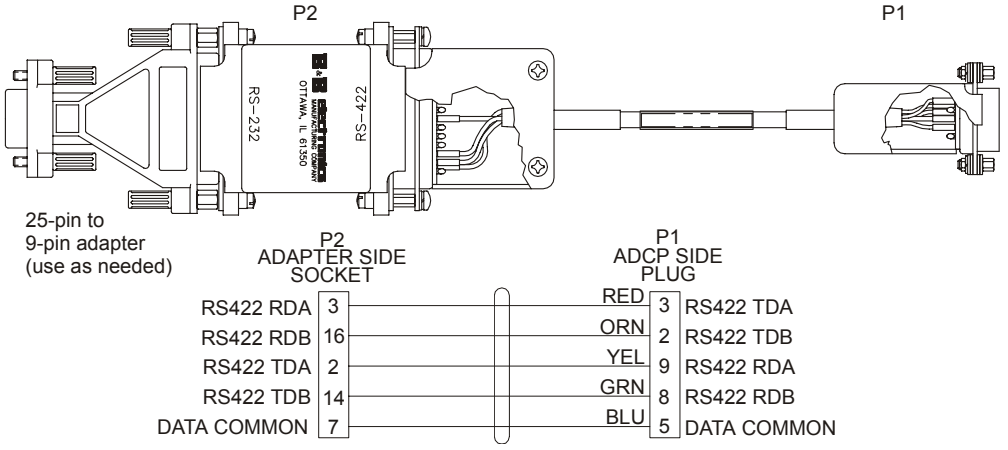


Figure 56. RS232-to-RS422 Converter Wiring (25-Pin to 9-Pin)

5.10 System Overview

This section presents a functional description of WorkHorse operation using block diagrams.

5.10.1 Operating Modes

The WorkHorse has two modes of operation: *command mode*, and *ping mode* (also referred to as "Deployment Saver" Mode). Depending on what mode the ADCP is in; it will go either to sleep, or to resume pinging.

Command Mode

Whenever you wake up your WorkHorse, power dissipation increases from less than 1 mW to around 2.2 W. If you leave the WorkHorse in command mode without sending a command for more than 5 minutes, the WorkHorse automatically goes to sleep. This protects you from inadvertently depleting batteries.

- If the ADCP receives a BREAK, it will go to the command prompt and wait for a command. The ADCP will wait at the command prompt for five minutes. If no commands have been sent, it will go to sleep (also called "Battery Saver" mode).
- If you press the reset switch (located on the CPU board), the ADCP will go to sleep.
- If the ADCP receives a CS-command, it will go into the ping mode and begin pinging. If a TF-command (Time of First Ping) was sent prior to the CS-command, then the ADCP will go to sleep until the TF time occurs.
- If the ADCP does a COLD wakeup (i.e. an unknown state), it will go to the command prompt.
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged (this only takes a few seconds), the ADCP goes back to sleep.

Ping Mode

After you send commands to the WorkHorse that tells it to start collecting data, the WorkHorse goes into deployment saver mode. If power is somehow removed and later restored, the WorkHorse simply picks up where it left off and continues to collect data using the same setup.

- If the ADCP receives a BREAK, it will go to the command prompt, but stays in the ping mode. If a valid command is received, the ADCP will switch to the command mode. If no valid command is received, a warning will be displayed after four minutes, indicating that the system will self-deploy. After a total of five minutes with no input, the ADCP will resume pinging.
- If you press the reset switch, and an alarm is currently set for the next ping, the ADCP will go to sleep. If no alarm is set, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs.

- If the ADCP does a COLD wakeup, the system will start a new deployment and starts pinging immediately unless a TF-command had been set after the last BREAK. In this case, the ADCP will go to sleep until the TF time occurs if the TF time is valid (i.e., not in the past).
- If the ADCP is asleep for approximately nine hours, it wakes up to charge the capacitor used to maintain RAM. Once the capacitor is charged, if a valid alarm is set for the next ping time, the ADCP goes back to sleep and waits for the alarm. If no alarm is set, the ADCP will resume pinging immediately, or wait for the TF time (if valid), and then start pinging.

5.10.2 Overview of Normal WorkHorse Operation

Refer to Figure 57, page 145 through Figure 60, page 148. The following events occur during a typical data collection cycle.

a. The user or a controlling software program sends data collection parameters to the WorkHorse. The user/program then sends a CS-command to start the data collection cycle. The firmware program stored in the CPU microprocessor takes control of WorkHorse operation based on the commands received through the serial I/O cable.

   Figure 57, page 145 shows a flow chart of the wake-up logic used by the WorkHorse. The WorkHorse determines what to do based on where the wake-up came from (a Break, CS-command, battery saver timer, or watchdog timer was detected).

b. On the PIO Board, the POWER REGULATOR circuit sends a transmit command to the POWER AMPLIFIER circuit. This tells the WorkHorse to start acoustic transmissions (pinging) on all TRANSDUCERS.

c. The TRANSDUCERS receive echoes from the backscatter. The RECEIVER board amplifies and translates the echoes into a base-band frequency.

d. The CPU board processes the received echoes.

e. After echo reception, the WorkHorse injects a self-test signal into the RECEIVER board and processes the signal as normal data for test purposes.

f. The THERMISTOR measures water temperature at the transducer head and sends it to the CPU via the DSP Board.

g. The PIO Board sends pitch and roll from the TILT SENSOR and WorkHorse heading from the COMPASS to the DSP Board. The DSP Board digitizes this information and sends it to the CPU for processing.

h. The CPU repeats steps “b” through “g” for a user-defined number of pings. The CPU averages the data from each ping to produce an ensemble data set.

i. At the end of the ensemble (sampling) interval, the CPU sends the collected data to the serial I/O connector or PCMCIA recorder.

5.10.3 Functional Description of Operation

The following paragraphs describe how the WorkHorse operates and interacts with its modules. Refer to Figure 57, page 145 through Figure 60, page 148 throughout this description.

Input Power

The Workhorse Monitor/Sentinel requires a DC supply between 20 volts and 50 volts. Either an external DC power supply or internal battery packs can provide this power. Figure 58, page 146 shows the DC voltage power distribution path.

Monitor External DC Power Supply – With an external supply, power is applied to pins 3 (positive) and 7 (negative) on the external connector (see Figure 59, page 147). The power then goes through an electromagnetic interference (EMI) filter on the PIO Board. This filter reduces the chance that external noise sources associated with the external power source can disrupt Workhorse operation.

Sentinel Internal Battery Packs – Each internal battery pack uses 28 alkaline “D” cells. Each pack supplies a nominal output voltage of 42 volts open circuit when fresh. The diode-isolated battery packs can only power the Workhorse; they cannot “charge” each other.

Mariner Deck Box – The deck box automatically scales the input voltage to the proper level. No special jumpers or switch settings are required to select the input voltage. If more than one power source is connected to the deck box, the highest voltage source will be used. Although this is not recommended, it will not damage the deck box.

AC Power. The deck box accepts input voltages of 98 to 264 VAC, 50 to 60Hz (J27). This input voltage will be converted to 48 VDC. This is the voltage supplied to the ADCP.

12 VDC Car Battery. Use a 12 VDC car battery (J26) when AC power is not available. The deck box converts the voltage to 48 VDC. This is the voltage supplied to the ADCP. Use the largest rated amp-hour battery as possible. A car battery should last one to two days powering a 1200-kHz River ADCP.

DC Power Supply. If you are using an external DC power supply connected to the deck box on J25 (20 to 50 VDC, 3.0 A), the voltage from

the external power supply is sent *directly* to the ADCP. This is useful if you want to increase (higher voltage level) or decrease (lower voltage level) the range of the ADCP. The current requirement for the power supply is listed as a reference. Using a lesser-rated power supply can cause the voltage level to drop. The ADCP will draw only the current it needs.

Board Descriptions

PIO Board.

- Receives the filtered/internal power.
- Uses a diode "OR" gate to determine which power source to use (external or internal). With both sources connected, the OR gate selects the "higher" voltage for Workhorse use.
- Limits the in-rush of current to the WorkHorse and provides over- and negative-voltage protection. Either condition will blow a protective fuse. However, damage could occur to other circuits before the fuse blows. Please ensure you apply only voltages within the specified range (+20 to +50 VDC).
- Converts the operating power supply (filtered/isolated 20 to 50 VDC or 5 to 18 VDC) in a DC-to-DC converter to the +5 VDC (Vcc) used to power all other WorkHorse circuits.
- Uses the Power Amplifier circuit on the PIO board to generate the high-amplitude pulse AC signal that drives the sonar transducers. The Power Amplifier sends the drive signal to the Receiver Board.
- RS-232/RS-422 switch.

CPU Board.

- Real time clock.
- Generates most of the timing and logic signals used by the WorkHorse.

DSP Board.

- Contains the PCMCIA recorder slots.
- Analog to Digital converter.
- Digitizes information from sensors and sends sensor information to the CPU.

Receiver Board.

- Tuning functions

- Receiver functions
- Temperature sensor
- Interface for pressure sensor

Sensors

This section describes the standard WorkHorse sensors. The PIO and DSP boards control the environmental sensors and contain unit-specific data. Sensors include:

Temperature Sensor (Thermistor) - Used to measure the water temperature. The system uses this data to calculate the speed of sound. This sensor is embedded in the transducer head and is not field replaceable.

Up/Down Sensor - Determines whether the transducer head is facing up or down. This sensor is located on the PIO board.

Compass - Determines the Beam 3 heading angle of the WorkHorse using a flux-gate compass. This sensor is located on the PIO board. The flux-gate measured earth magnetic field vector together with the tilt sensor pitch and roll information is used to determine the heading. Since the tilt sensor data is only valid when the ADCP is ±20° from vertical, the heading information is also limited to this range.

Attitude Sensor - Determines the tilt angles of the WorkHorse. This sensor is located on the PIO board. The attitude sensor uses a pitch and roll liquid-filled sensor. This sensor is functional to an angle of ±20° from vertical.

Pressure Sensor (optional) - Measures pressure at the WorkHorse transducer. This sensor is embedded in the transducer head and is not field replaceable.

The CPU microprocessor controls a multiplexed analog-to-digital converter to accept analog data from the sensors. Digital data are taken in directly. The pressure sensor incorporates a Wheatstone Bridge strain gage to measure the water pressure at the transducer faces. Depth is calculated from pressure, with water density adjusted by the salinity (ES) setting.

Calibration data for the sensors, a beam-angle correction matrix, and unit identification parameters (frequency, serial number, firmware version, etc.) are stored in ROM.

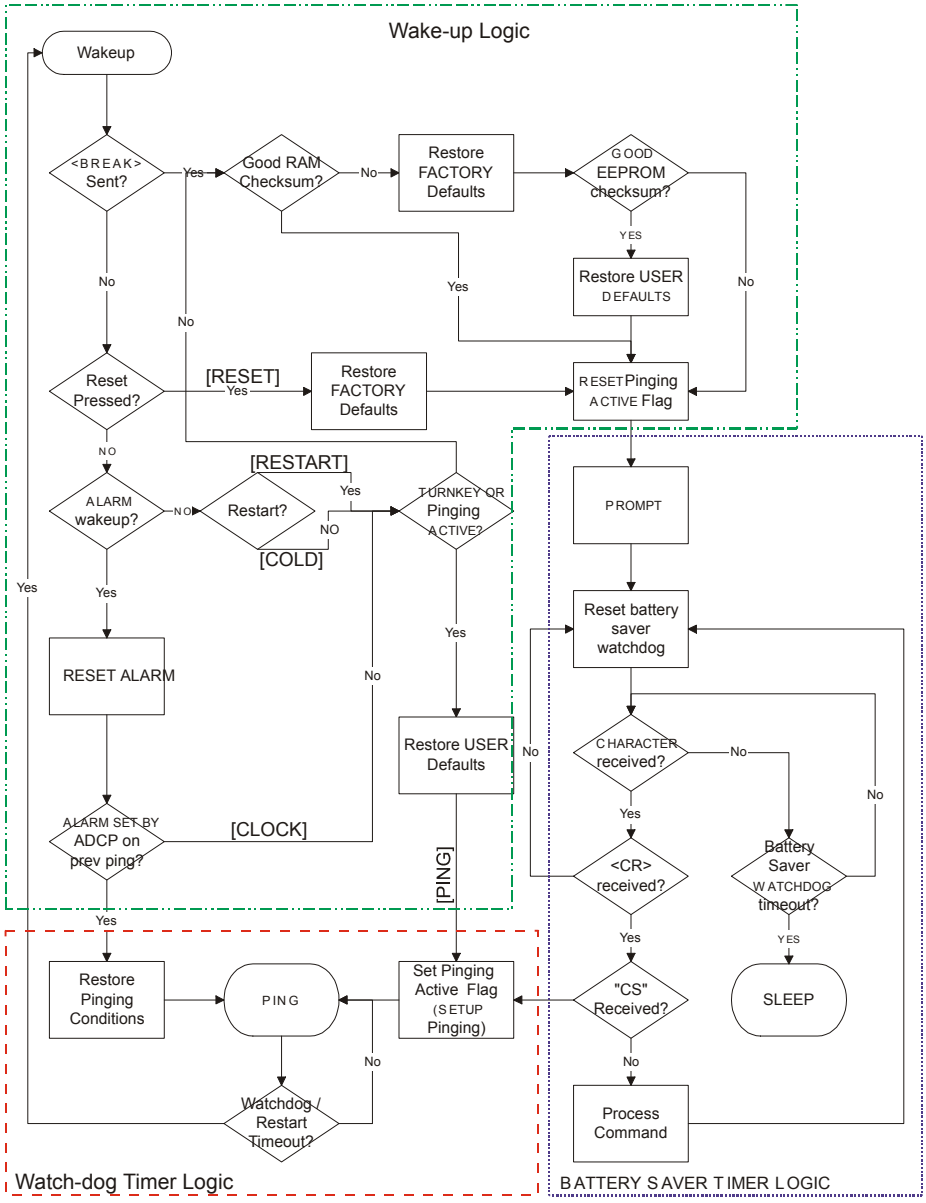


Figure 57. WorkHorse Wake-up and Timer Logic

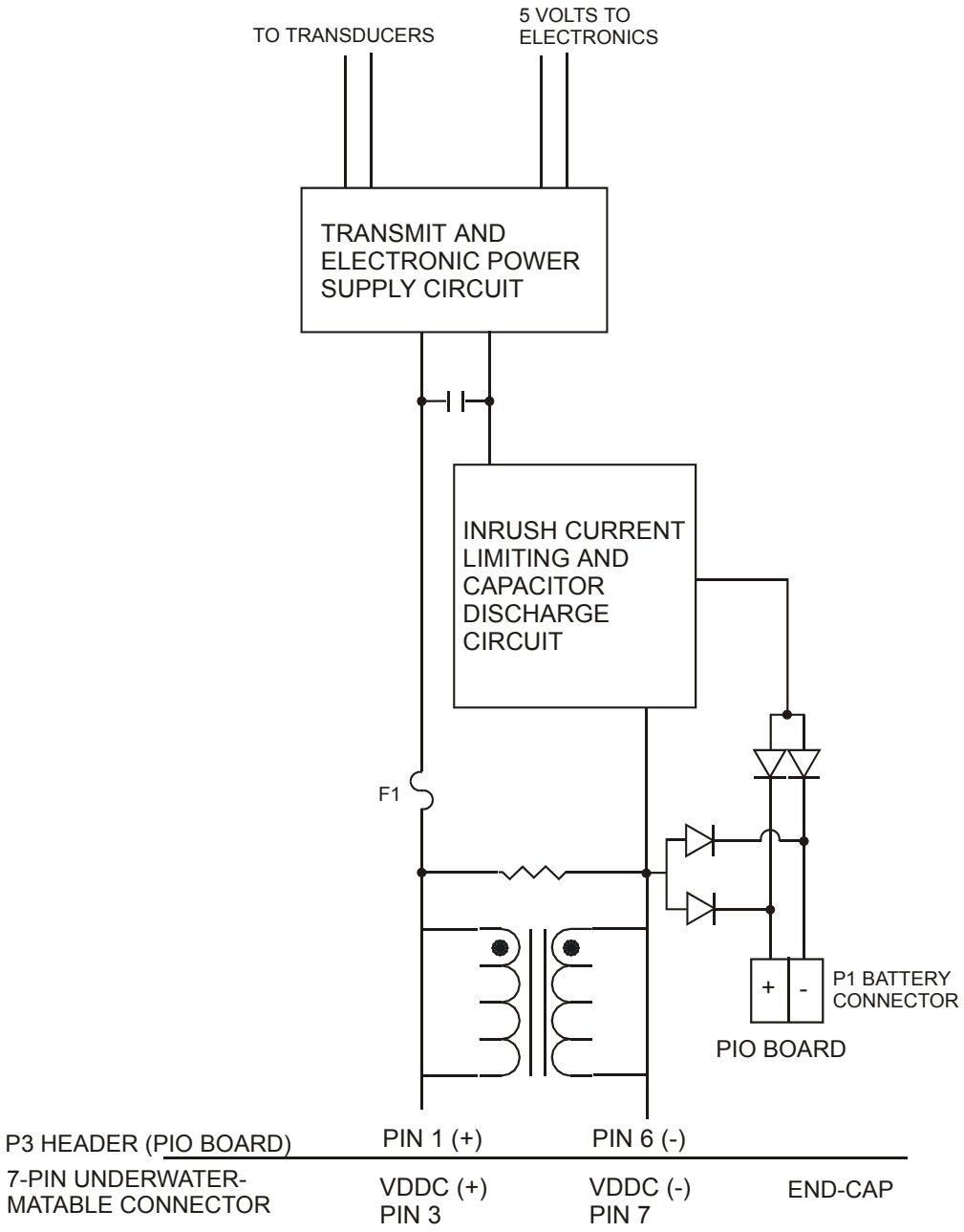


Figure 58. Mariner/Monitor/Sentinel DC Power Path

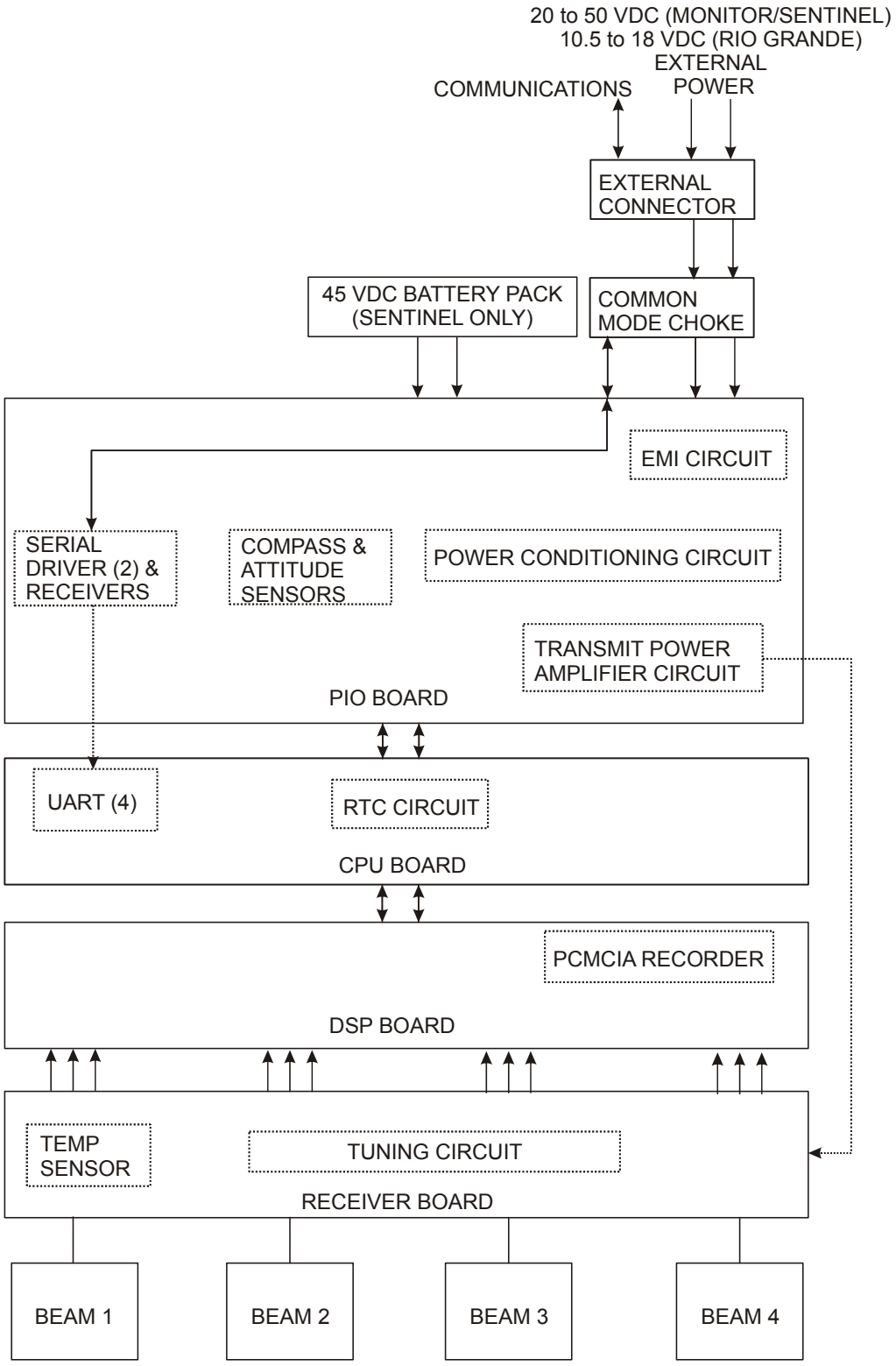


Figure 59. WorkHorse Block Diagram

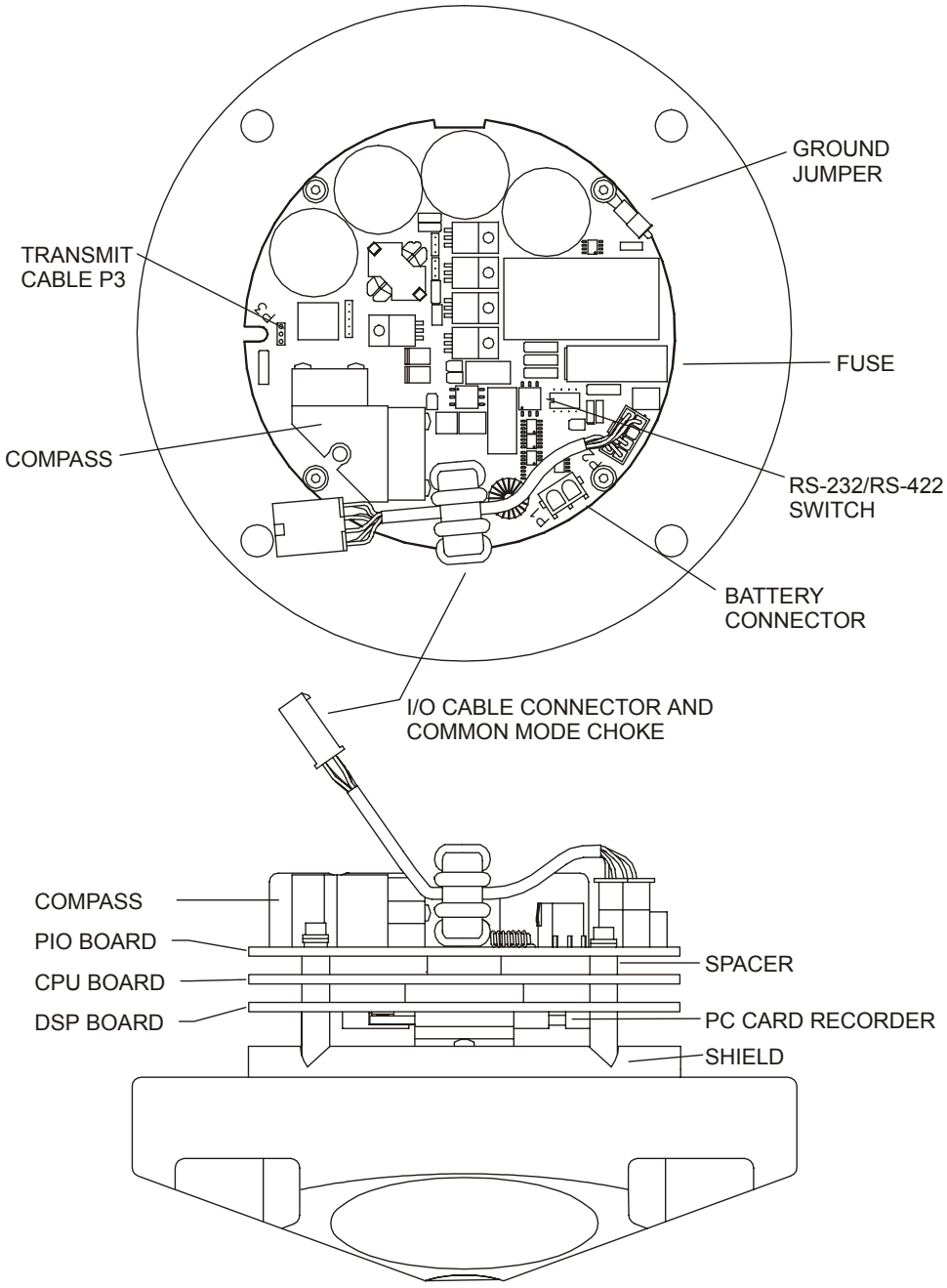


Figure 60. WorkHorse PC Board Locations

6 Returning WorkHorses to TRDI for Service

When shipping the WorkHorse to TRDI from either inside or outside the United States, the following instructions will help ensure the WorkHorse arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

6.1 USA and Non-European Shipments

Step 1 - Get a Return Material Authorization

The best way to make sure TRDI is aware of your intentions to ship equipment is to obtain a Return Material Authorization (RMA) before sending the shipment. Return Material Authorizations are issued by Sales Administration or Customer Service (rdicsadmin@teledyne.com) and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Material Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Material Authorization is issued, we will tell you the RMA number. Please include this number on all packages and correspondence.

Step 2 - Ship via air freight, prepaid

Urgent Shipments should be shipped direct to TRDI via any of several overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to three days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money. In addition, some truck lines may offer equivalent delivery service at a lower cost, depending on the distance to San Diego.

Mark the Package(s)

To: Teledyne RD Instruments, Inc. (RMA Number)
14020 Stowe Drive
Poway, California 92064

Airport of Destination = San Diego
Notify Paxton, Shreve, and Hayes, San Diego Airport
Phone +1 (619) 692-3113
Fax: +1 (619) 692-0539

Step 3 - Urgent shipments

Send the following information by fax or telephone to TRDI.

Attention: Customer Service Administration
Fax: +1 (858) 842-2822
Phone: +1 (858) 842-2600

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

6.2 European Shipments

Step 1 - Get a Return Material Authorization

The best way to make sure TRDI is aware of your intentions to ship equipment is to obtain a Return Material Authorization (RMA) before sending the shipment. Return Material Authorizations are issued by Sales Administration or Customer Service (rdicsadmin@teledyne.com) and are used to notify us of your needs in advance of arrival so we can provide a faster turnaround. When requesting a Return Material Authorization, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What problem(s) need correction
- When you need the instrument returned

When the Return Material Authorization is issued, we will tell you the RMA number. Please include this number on all packages and correspondence.

Step 2 - Ship Via Air Freight, Prepaid

Urgent Shipments should be shipped direct. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, you will save money, but may lose up to five days in transit time.

Non-urgent shipments may be shipped as part of a consolidated cargo shipment to save money.

Mark the package(s) as follows:

To: Teledyne RD Instruments, Inc. (RMA Number)
2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Step 3 - Include Proper Customs Documentation

The Customs statement should be completed very carefully. It should accurately and truthfully contain the following information.

- Contents of the shipment
- Value
- Purpose of shipment (example: "American made goods returned for repair")
- Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

Step 4 - Send the Following Information by Fax or Telephone to TRDI Europe

Attention: Sales Administration
Phone: +33(0) 492-110-930
Fax: +33(0) 492-110-931

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

7 Specifications

A brief review of ADCP operation may help you understand the specifications listed in this section.

NOTE. The specifications and dimensions listed in this section are subject to change without notice.

The ADCP emits an acoustic pulse called a PING. Scatterers that float ambiently with the water currents reflect some of the energy from the ping back to the ADCP. The ADCP uses the return signal to calculate a velocity. The energy in this signal is the *echo intensity*. Echo intensity is sometimes used to determine information about the scatterers.

The velocity calculated from each ping has a *statistical uncertainty*; however, each ping is an independent sample. The ADCP reduces this statistical uncertainty by averaging a collection of pings. A collection of pings averaged together is an *ensemble*. The ADCP's maximum *ping rate* limits the time required to reduce the statistical uncertainty to acceptable levels.

The ADCP does not measure velocity at a single point; it measures velocities throughout the water column. The ADCP measures velocities from its transducer head to a specified range and divides this range into uniform segments called *depth cells* (or *bins*). The collection of depth cells yields a *profile*. The ADCP produces two profiles, one for velocity, and one for echo intensity.

The ADCP calculates velocity data relative to the ADCP. The velocity data has both speed and direction information. If the ADCP is moving, and is within range of the bottom, it can obtain a velocity from returns off the bottom. This is called *bottom tracking*. The bottom track information can be used to calculate the absolute velocity of the water. The ADCP can get absolute direction information from a heading sensor.

The following tables list the specifications for the WorkHorse ADCP. About the specifications:

a. All these specifications assume minimal ADCP motion - pitch, roll, heave, rotation, and translation.

b. Except where noted, this specification table applies to typical setups and conditions. Typical setups use the default input values for each parameter (exceptions include Pings Per Ensemble and Number of Depth Cells). Typical conditions assume uniform seawater velocities at a given depth, moderate shear, moderate ADCP motion, and typical echo intensity levels.

c. The total measurement error of the ADCP is the sum of:

- Long-term instrument error (as limited by instrument accuracy).
- The remaining statistical uncertainty after averaging.
- Errors introduced by measurement of ADCP heading and motion.

d. Because individual pings are independent, the statistical uncertainty of the measurement can be reduced according to the equation:

$$\frac{\text{Statistical Uncertainty for One Ping}}{\sqrt{\text{Number of Pings}}}$$

Table 28: Broad Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz		Nominal range 55m[2] 600 kHz		Nominal range 135m[2] 300k Hz	
Vertical Resolution	Range[3] (m)	Std. dev.[4] (cm/s)	Range[3] (m)	Std. dev.[4] (cm/s)	Range[3] (m)	Std. dev.[4] (cm/s)
0.25m	11.27	1.93				
0.50m	12.36	0.98	38.18	1.93		
1.0m	13.67	0.50	42.01	0.99	83.25	1.92
2.0m	15.12	0.24	46.49	0.51	92.62	0.98
4.0m			51.50	0.25	103.66	0.50
8.0m					116.10	0.24

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Broad bandwidth mode is set with the WB command (WB0 by default).
3. Range, which depends on cell size, is specified here for Broad bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Broad bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to WorkHorse Monitor/Sentinel/Mariner ADCPs.

Table 29: Narrow Bandwidth Water Profiling

Depth Cell Size[1]	Nominal range 15m[2] 1200 kHz		Nominal range 55m[2] 600 kHz		Nominal range 135m[2] 300 kHz	
Vertical Resolution	**Range[3] (m)**	**Std. dev.[4] (cm/s)**	**Range[3] (m)**	**Std. dev.[4] (cm/s)**	**Range[3] (m)**	**Std. dev.[4] (cm/s)**
0.25m	14.74	3.77				
0.50m	15.97	1.93	52.02	4.04		
1.0m	17.41	0.98	56.33	2.07	117.42	4.02
2.0m	18.96	0.48	61.27	1.06	128.11	2.05
4.0m			66.72	0.51	140.63	1.05
8.0m					154.39	0.52

NOTES
1. User's choice of depth cell size is not limited to the typical values specified.
2. Narrow bandwidth mode is set with the WB command (WB1).
3. Range, which depends on cell size, is specified here for Narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power. Using 48 VDC will increase the range by 5 to 10% depending on conditions.
4. Narrow bandwidth mode 50 water pings per ensemble standard deviation.
5. Table applies to WorkHorse Monitor/Sentinel/Mariner ADCPs.

Table 30: WorkHorse Range

	Range (m) @ 32VDC	Range (m) @ 48VDC	Depth Cell Size (m)
1200kHz	18.96	20.4	2
600kHz	66.72	70.9	4
300kHz	140.63	167.7	8

Range, which depends on cell size, is specified here for narrow bandwidth mode at 5° C, typical ocean backscatter, and nominal 32 VDC battery power (Sentinel) and 48VDC input power (Mariner/Monitor).

Table 31: Bottom Track Profile Parameters

System Frequency	1200 kHz	600 kHz	300 kHz
Maximum Altitude (m)	30	100	260
Minimum Altitude (m)	0.8 (Mariner)	1.4 (Mariner)	2

Table 32: Profile Parameters

Velocity accuracy	
1200 and 600 kHz	± 0.25% of the water velocity relative to the ADCP ± 2.5mm/s
300 kHz	± 0.5% of the water velocity relative to the ADCP ± 5 mm/s
Velocity resolution	l mm/s
Velocity range	± 5m/s (default), ± 20m/s (maximum)
Number of depth cells	1 to 128
Ping rate	2 Hz (typical)

Table 33: Echo Intensity Profile

Vertical resolution	Depth cell size
Dynamic range	80 dB
Precision	± 1.5dB (relative measure)

Table 34: Standard Sensors

Temperature (mounted on transducer)

Range: -5° to 45° C

Precision: ± 0.4° C

Resolution: 0.01°

Tilt

Range: ± 15°

Accuracy: ± 0.5°

Precision: ± 0.5°

Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)

Accuracy: ± 2°[1]

Precision: ± 0.50[1]

Resolution: 0.01°

Maximum tilt: ± 15°

Note: 1) @ 60° magnetic dip angle, 0.5G total field

Table 35: Transducer and Hardware

Beam angle	20°
Configuration	4 beam, convex
Internal memory	Memory card not included with Monitor, and Mariner models. Sentinel and Long Ranger ADCPs come standard with one memory card. Two PCMCIA memory card slots are available, with the total memory capacity not to exceed 2GB.
Communications	Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200 to 115,200 baud.

Table 36: Environmental Specifications

Operating temperature with or without batteries	-5° to 45°C
Short Term Storage/Shipping (<45days) temperature (Batteries Installed)	-5° to 45°C
Long Term Storage (>45days) temperature (Batteries Installed)	O° C to 21° C
Long Term Storage (>45days) temperature (Batteries Removed)	-30° to 60°C
Long Term (>45days) Battery Storage	Batteries should be stored in cool dry air with a temperature range of O° C to 21° C.
Battery Shelf Life	Use within one year.

CAUTION. Batteries stored for more than 12 months should NEVER be used!

NOTE. Batteries less than 12 months old may be used for any length deployment. For example, if your deployment is going to be 12 months long and the battery label shows it is nine months old, it is safe to use the battery.

Table 37: Power

System	Specification
Sentinel	
DC input	20 to 50 VDC external power supply
Battery Voltage	42 VDC (new), 28 VDC (depleted)
Battery Capacity	400 watt hours @ 0° C
External Battery Pack	42 VDC (new), 28 VDC (depleted). Holds up to two 400 watt hour batteries
Transmit	16W @ 35V (1200kHz), 37W @ 35V (600kHz), 115W @ 35V (300kHz)
Monitor	
DC input	20 to 50 VDC external power supply or 42 VDC External Battery Pack
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)
Mariner	
Deck Box Input	12 VDC, 20 to 50V DC external power supply, 110 to 220 VAC
Transmit	22W @ 48V (1200kHz), 60W @ 48V (600kHz), 190W @ 48V (300kHz)

8 Outline Installation Drawings

The following drawings show the standard Workhorse Monitor, Sentinel, Mariner, and Mariner Deck Box dimensions and weights.

Table 38: Outline Installation Drawings

Description	Drawing #
Mariner Deck Box	961-6031
External Battery Case	967-6007
6000 meter WorkHorse Monitor	967-6008
6000 meter WorkHorse Sentinel	967-4002
1000 meter WorkHorse	967-6009
1200 kHz Mariner	967-6032
300/600 kHz Mariner	967-6033
1200 kHz Monitor/Sentinel	967-6034
300/600 kHz Monitor/Sentinel	967-6035
300/600 kHz 500 meter Monitor/Sentinel	967-6044
1200 kHz 500 meter Monitor/Sentinel	967-6045

NOTE. If you are having difficulty reading the text on the Outline Installation drawings, please use the electronic documentation. The documentation CD allows you to zoom in and rotate the graphics.

CAUTION. Outline Installation Drawings are subject to change without notice. Verify you have the latest version of the drawing by contacting TRDI before building mounts or other hardware.

961-6031

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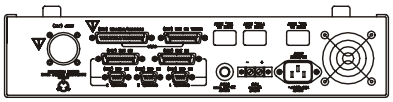
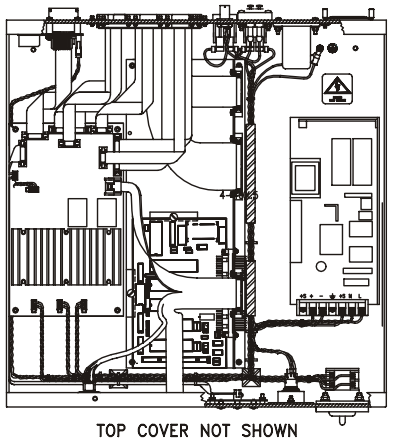
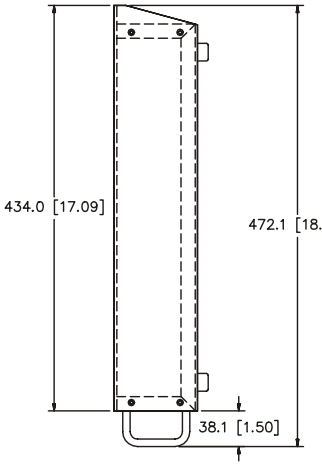
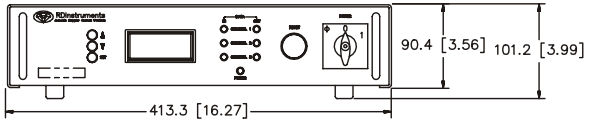
REVISIONS				
ECO #	REV	DESCRIPTION	DATE	APPROVED
	A	DWG CREATED AT THIS REV.		
	B	Updated silk screen – show gyro interface. P. Walters 001122		





TOP COVER NOT SHOWN





DIMENSION FORMAT: MILLIMETERS [INCHES]
OPTIONAL GYRO INTERFACE SHOWN

THIRD ANGLE PROJECTION

DASH NO | NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS
TOLERANCES:
DECIMALS .X ±0.8
.XX ±0.13
ANGLES 1.5°
DRILLED HOLES
#0–#12.7: +.13 –.05
#12.71–#25.4: +.20 –.10
DO NOT SCALE DRAWING

CONTRACT NO.

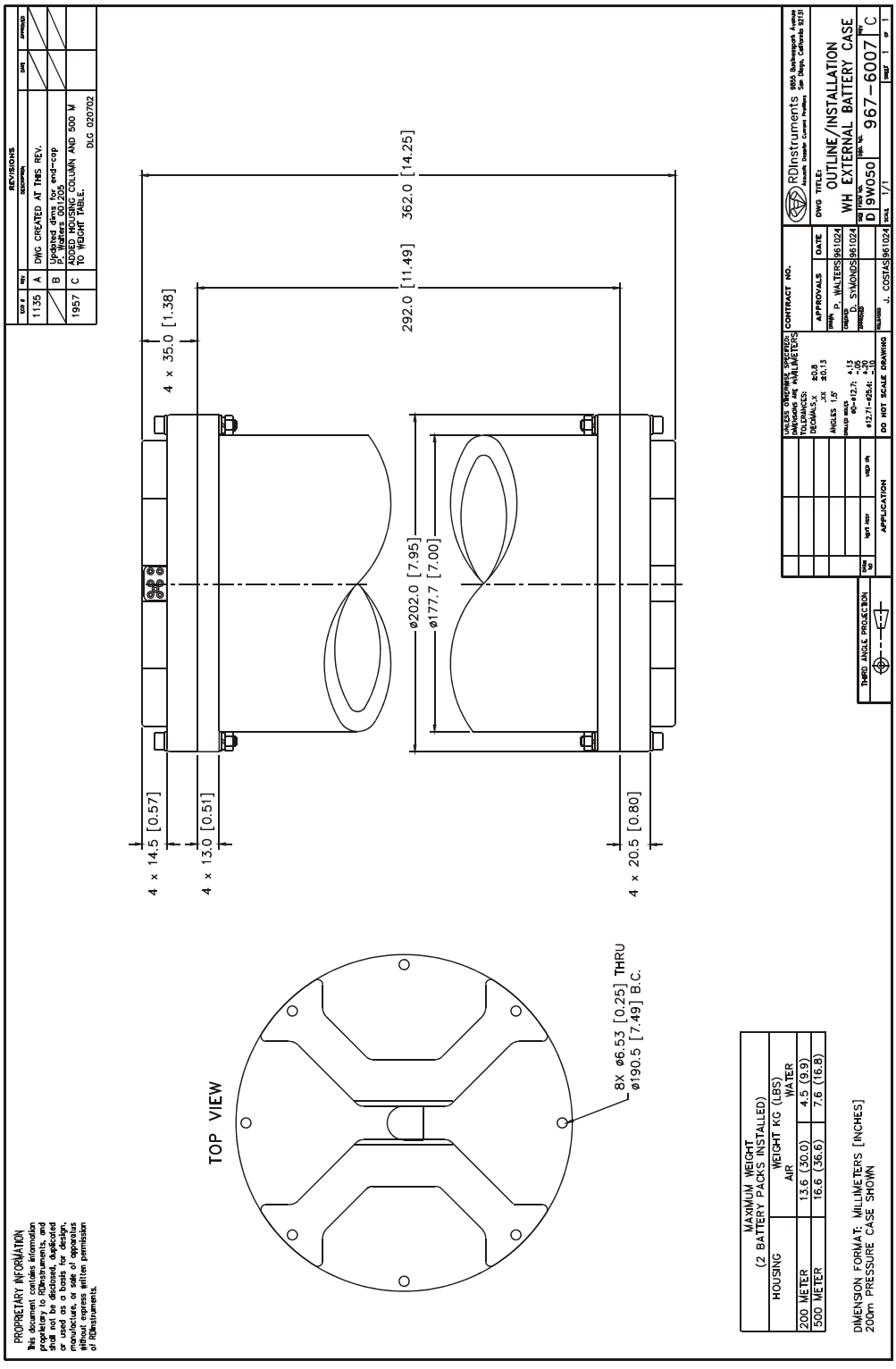
APPROVALS	DATE
DRAWN P. WALTERS	970314
CHECKED D. SYMONDS	970314
APPROVED	
RELEASED J. COSTAS	970314

RDInstruments 9855 Businesspark Avenue San Diego, California 92131
Acoustic Doppler Current Profilers

DWG TITLE:
OUTLINE/INSTALLATION
DR DECK BOX

SIZE D | FSCM NO. 9W050 | DWG. NO. 961-6031 | REV B
SCALE 1/2 | SHEET 1 OF 1

967-6007


REVISIONS
DWG CREATED AT THIS REV.
Updated dims for end-cap
ADDED 4000/2000 COLUMN AND 500 M TO WEIGHT TABLE.
DLG 020702
4 x 14.5 [0.57]
4 x 13.0 [0.51]
4 x 35.0 [1.38]
292.0 [11.49]
362.0 [14.25]
ø202.0 [7.95]
ø177.7 [7.00]
4 x 20.5 [0.80]
TOP VIEW
8X ø6.53 [0.25] THRU
ø190.5 [7.49] B.C.
MAXIMUM WEIGHT
(2 BATTERY PACKS INSTALLED)
HOUSING
WEIGHT KG (LBS)
AIR
WATER
200 METER
13.6 (30.0)
4.5 (9.9)
500 METER
16.6 (36.6)
7.6 (16.8)
DIMENSION FORMAT: MILLIMETERS [INCHES]
200m PRESSURE CASE SHOWN
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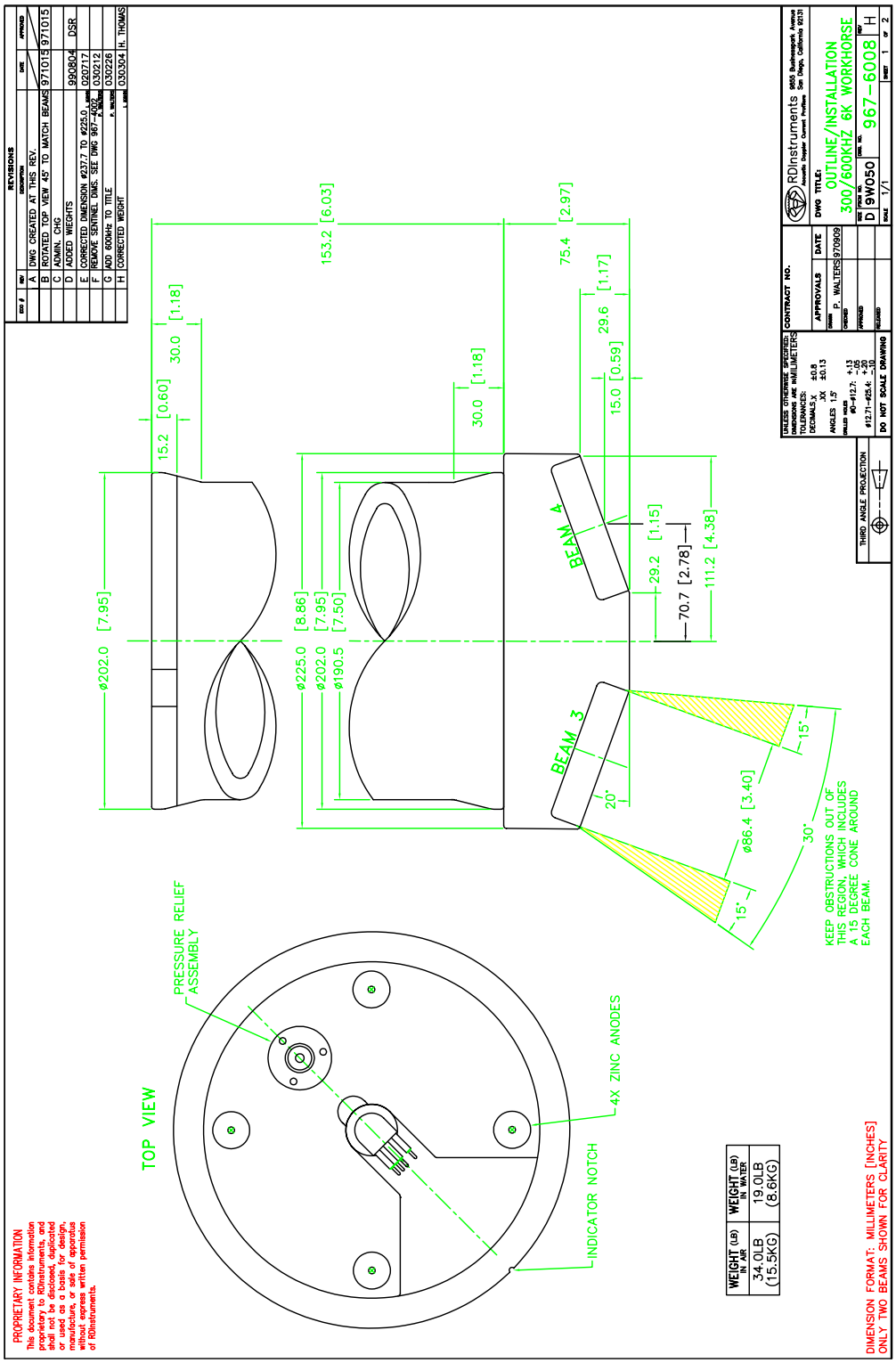
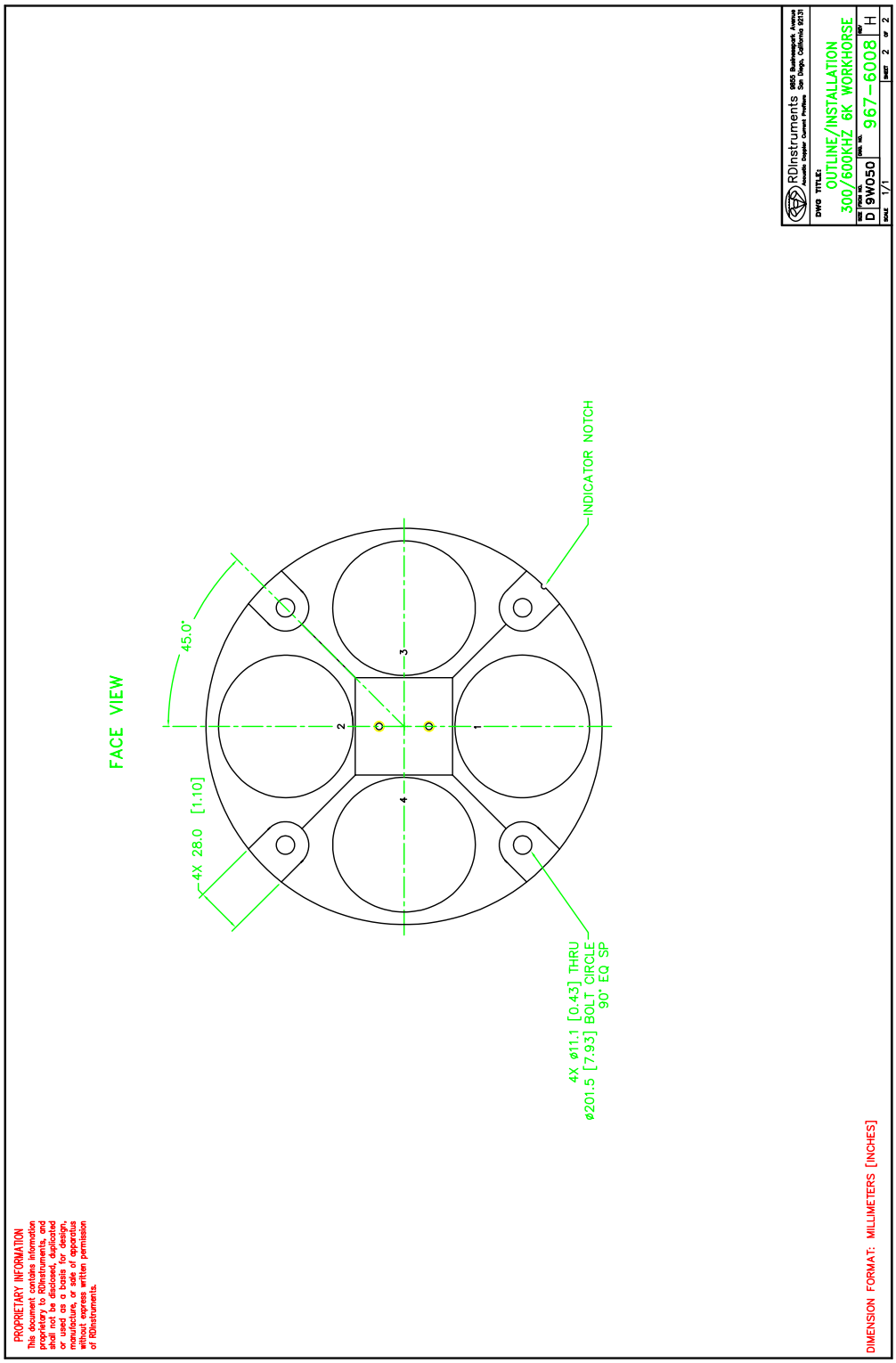
THIRD ANGLE PROJECTION
APPLICATION
DO NOT SCALE DRAWING
CONTRACT NO.
APPROVALS
DRWN A. WALTERS 961024
CHKD D. SYMONDS 961024
ENGRG
MFGR
ISSUED J. COSTAS 961024
RDInstruments 9855 Businesspark Avenue Acoustic Doppler Current Profilers San Diego, California 92131
DWG TITLE:
OUTLINE/INSTALLATION
WH EXTERNAL BATTERY CASE
SIZE D
DWG NO. 9W050
967-6007
REV C
SHEET 1 OF 1

967-6008 Sheet 1



967-6008 Sheet 2



967-4002

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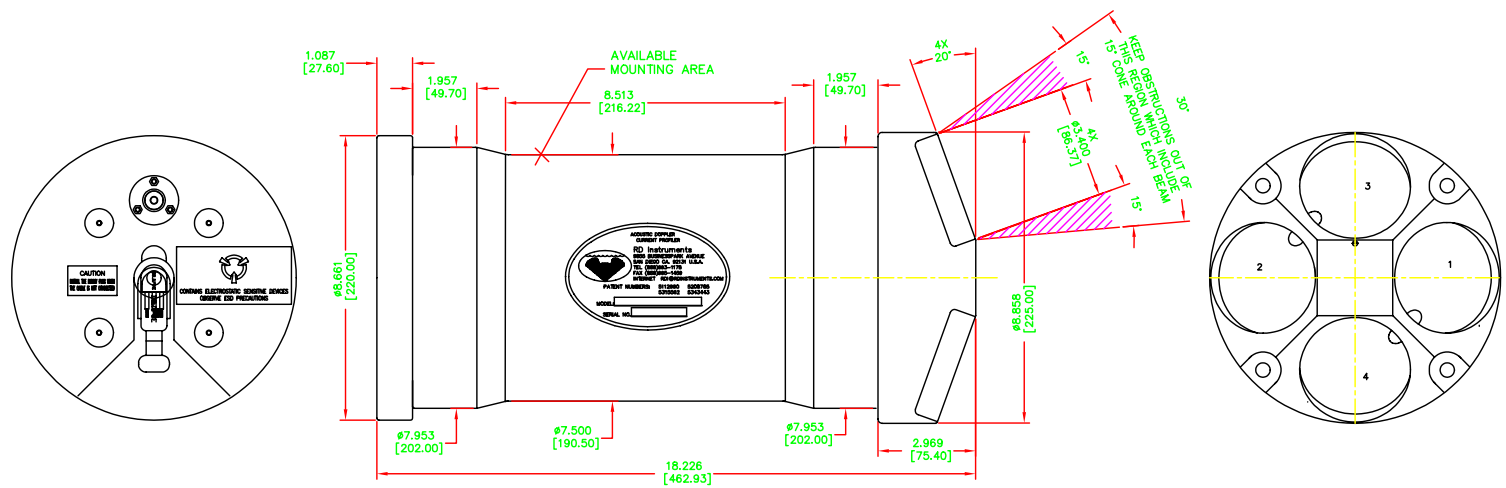
REVISIONS

ENGRG AUTH	REV	DESCRIPTION	DATE	APPROVED
	XA	PROTOTYPE RELEASE	010921	
	XB	MODIFIED HOUSING FOR ANODE I. KAHN	030114	
	XC	ADDED 300/600kHz TO TITLE P. SHULTZ	030226	



	HOUSING	HOUSING W/ 1 BATT. PACK	HOUSING W/ 2 BATT. PACK
IN AIR	45LB (20.5KG)	54LB (24.6KG)	62LB (28.3KG)
IN H_2O	14LB (6.5KG)	23LB (10.5KG)	31LB (14.2KG)

1. DIMENSIONS ARE IN INCHES[MILLI METERS].

NOTES: UNLESS OTHERWISE SPECIFIED

THIRD ANGLE PROJECTION

DASH NO | NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES, ø3
TOLERANCES:
DECIMALS: .XX ±0.010
.XXX ±0.005
ANGLES: 1.5°
DRILLED HOLES: ø0–ø0.50: +0.005 −0.002
ø0.50–ø1.00: +0.007 −0.003

DO NOT SCALE DRAWING

CONTRACT NO.

APPROVALS		DATE
DRAWN	I. KAHN	09/21/01
DESIGNED	I. KAHN	08/16/01
QA APPROVED		
RELEASED		

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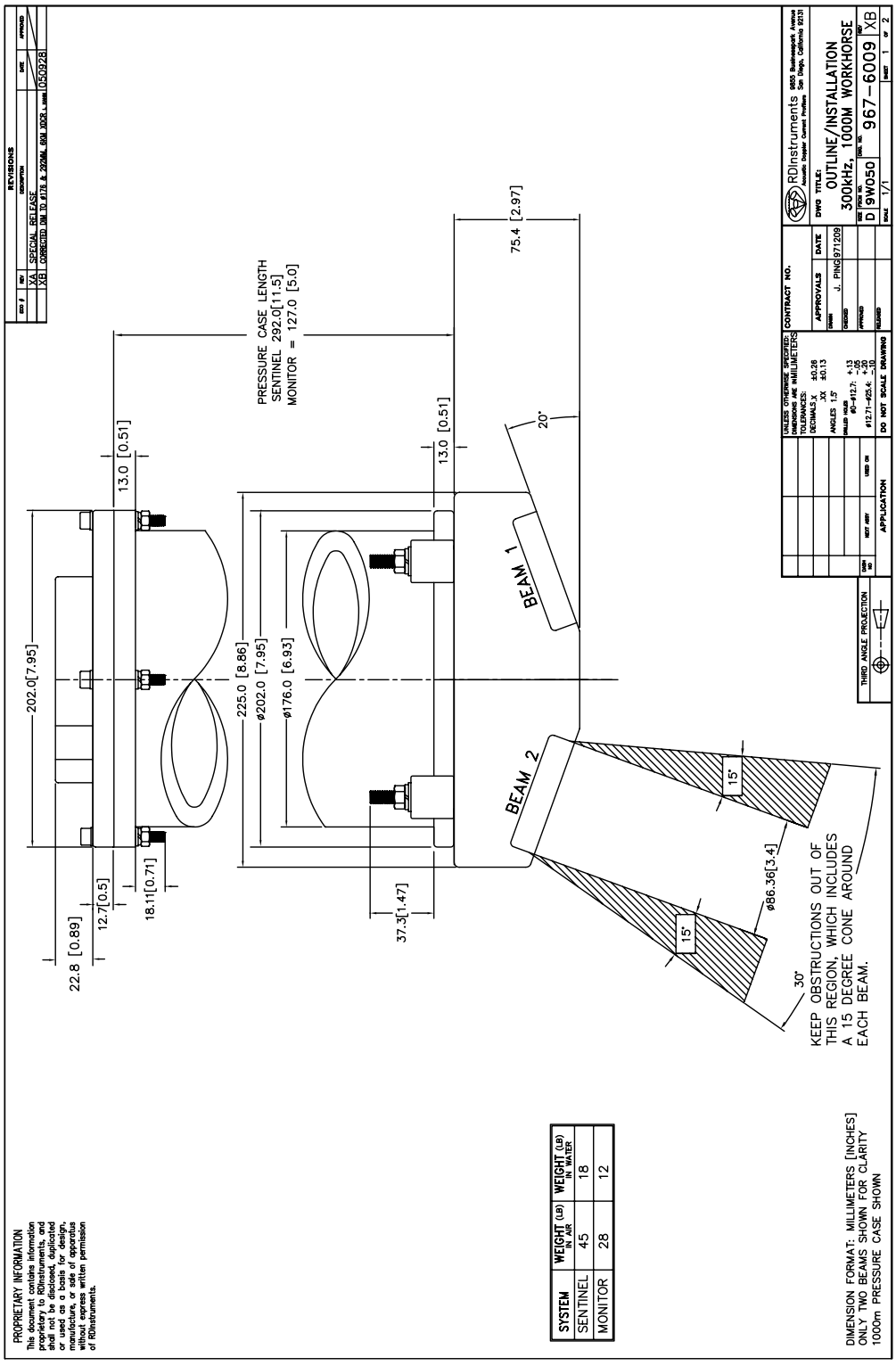
Acoustic Doppler Current Profilers

OUTLINE/INSTALLATION, 6 KM, 300/600kHz WH SENTINEL

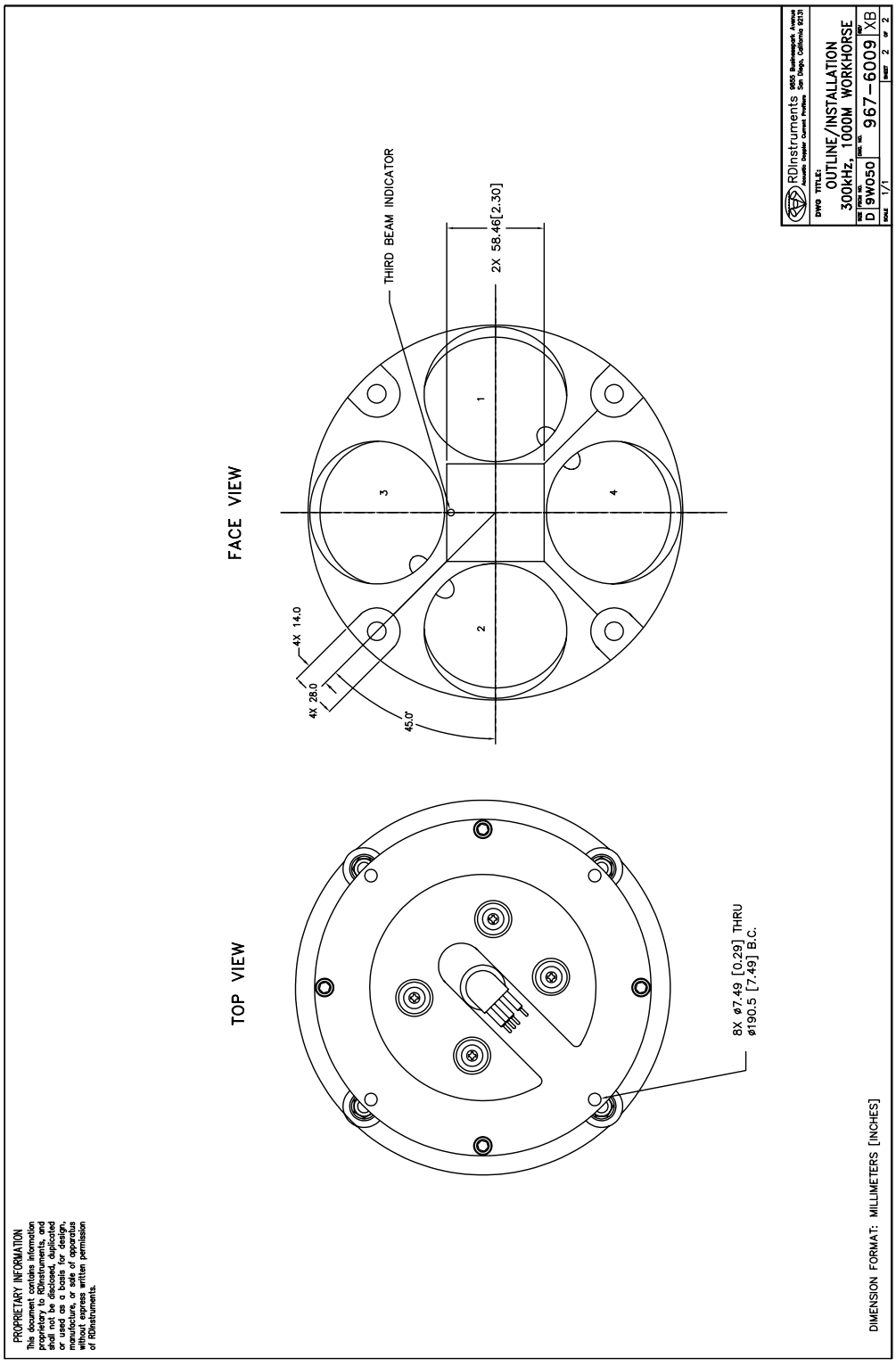
SIZE D | FSCM NO. 9W050 | DWG. NO. 967-4002-00 | REV XC

SCALE 1/1 & NOTED | SHEET 1 OF 1

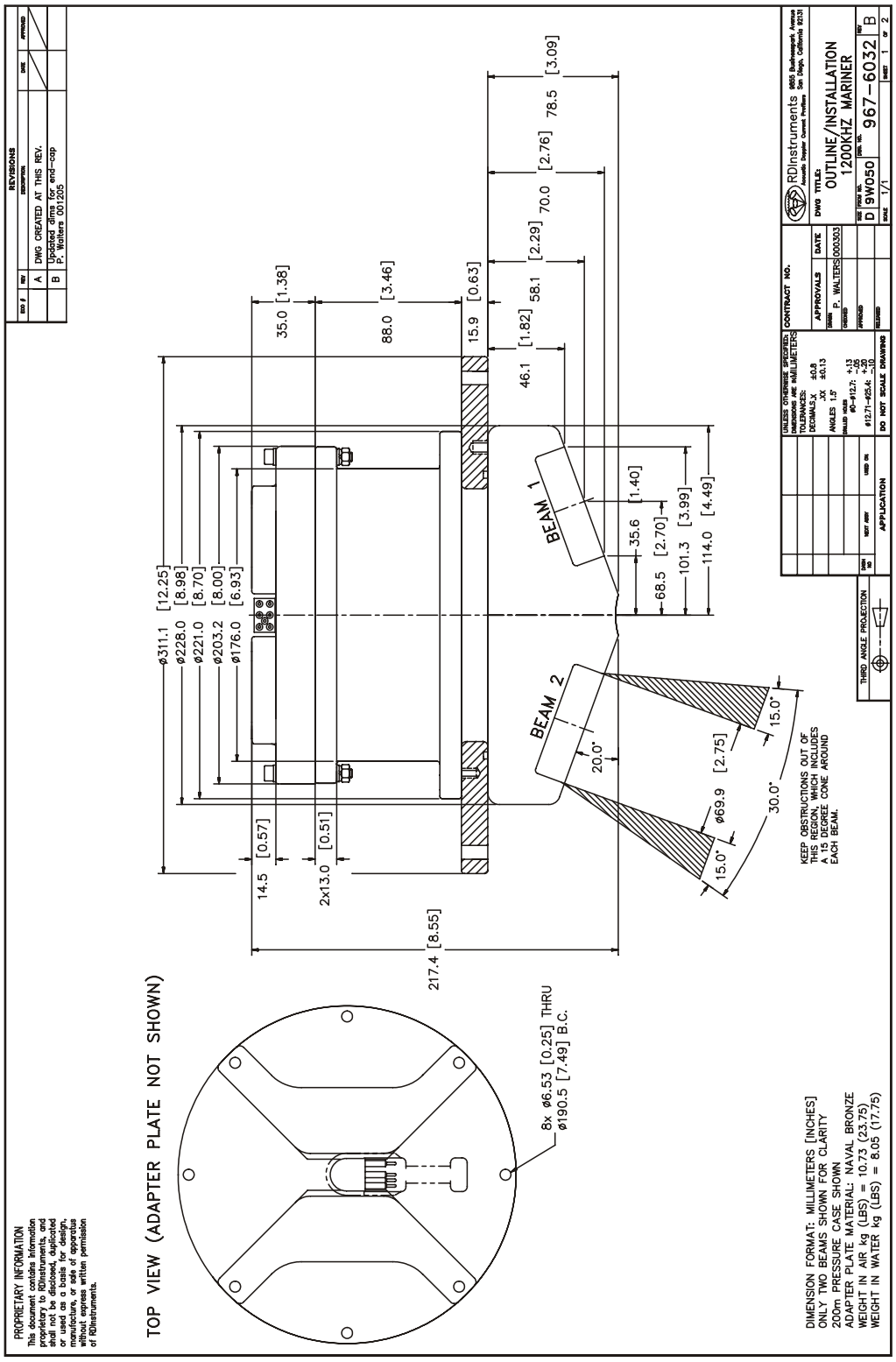
967-6009 Sheet 1



967-6009 Sheet 2



967-6032 Sheet 1



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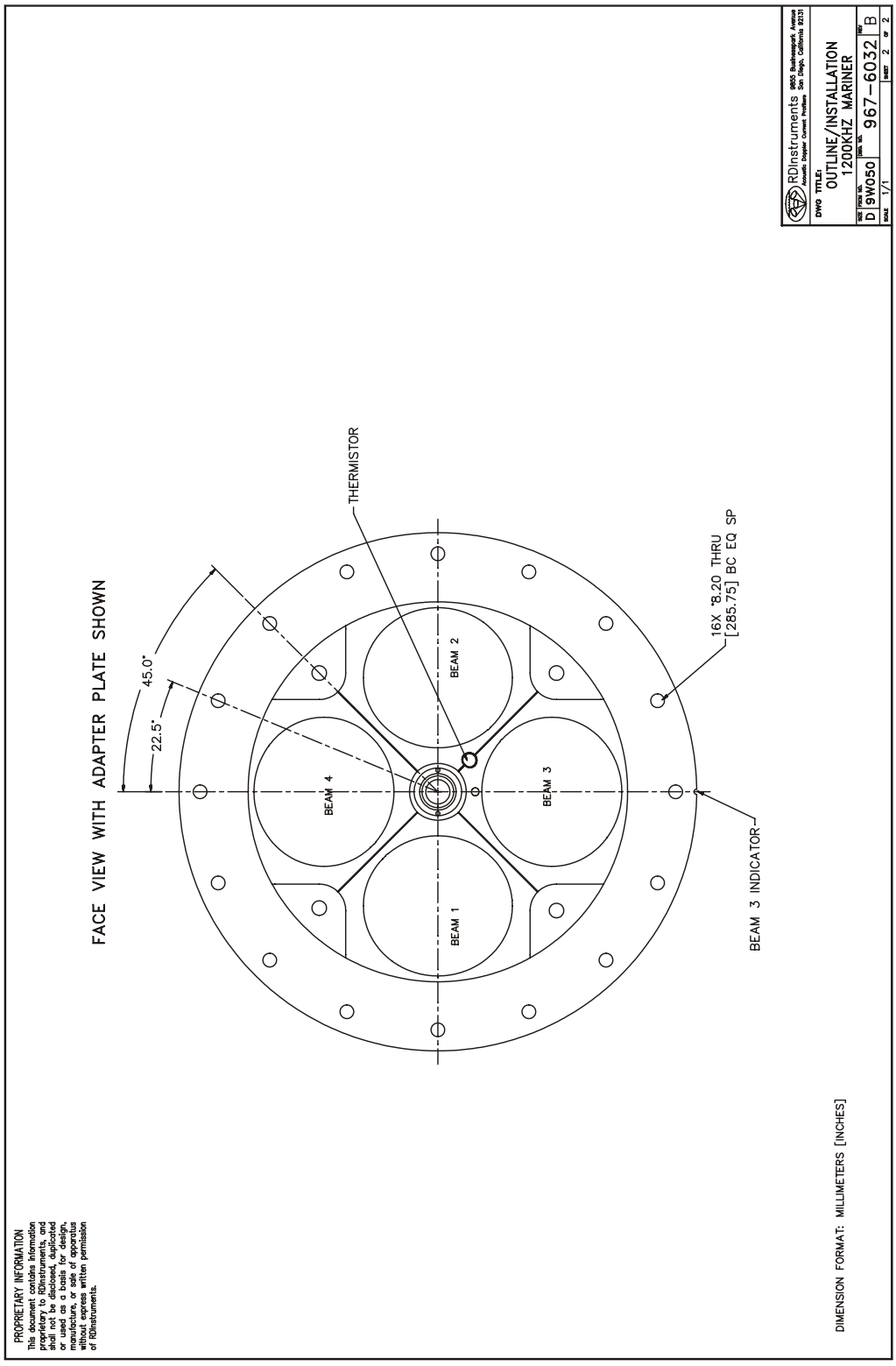
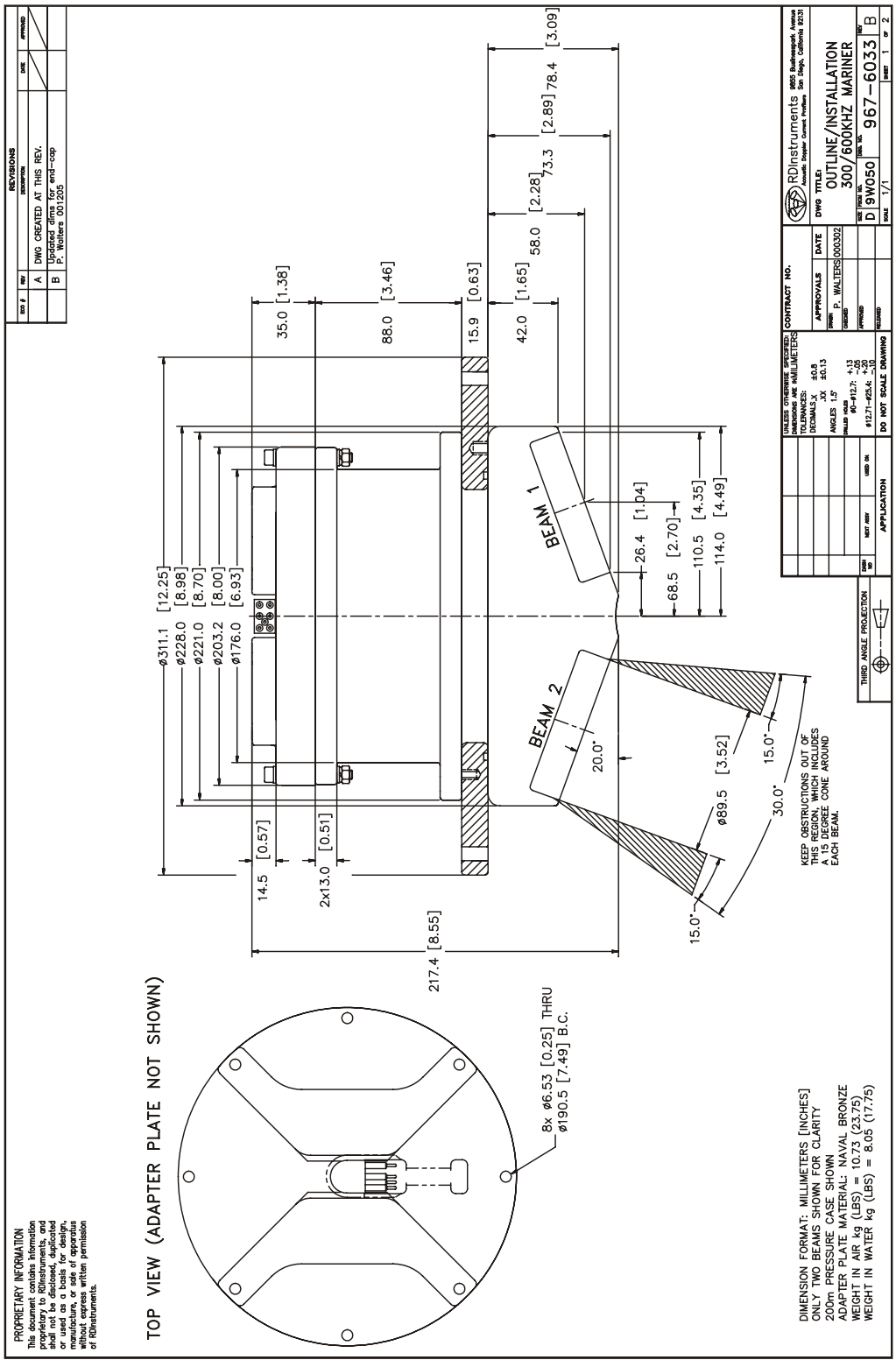


967-6033 Sheet 1



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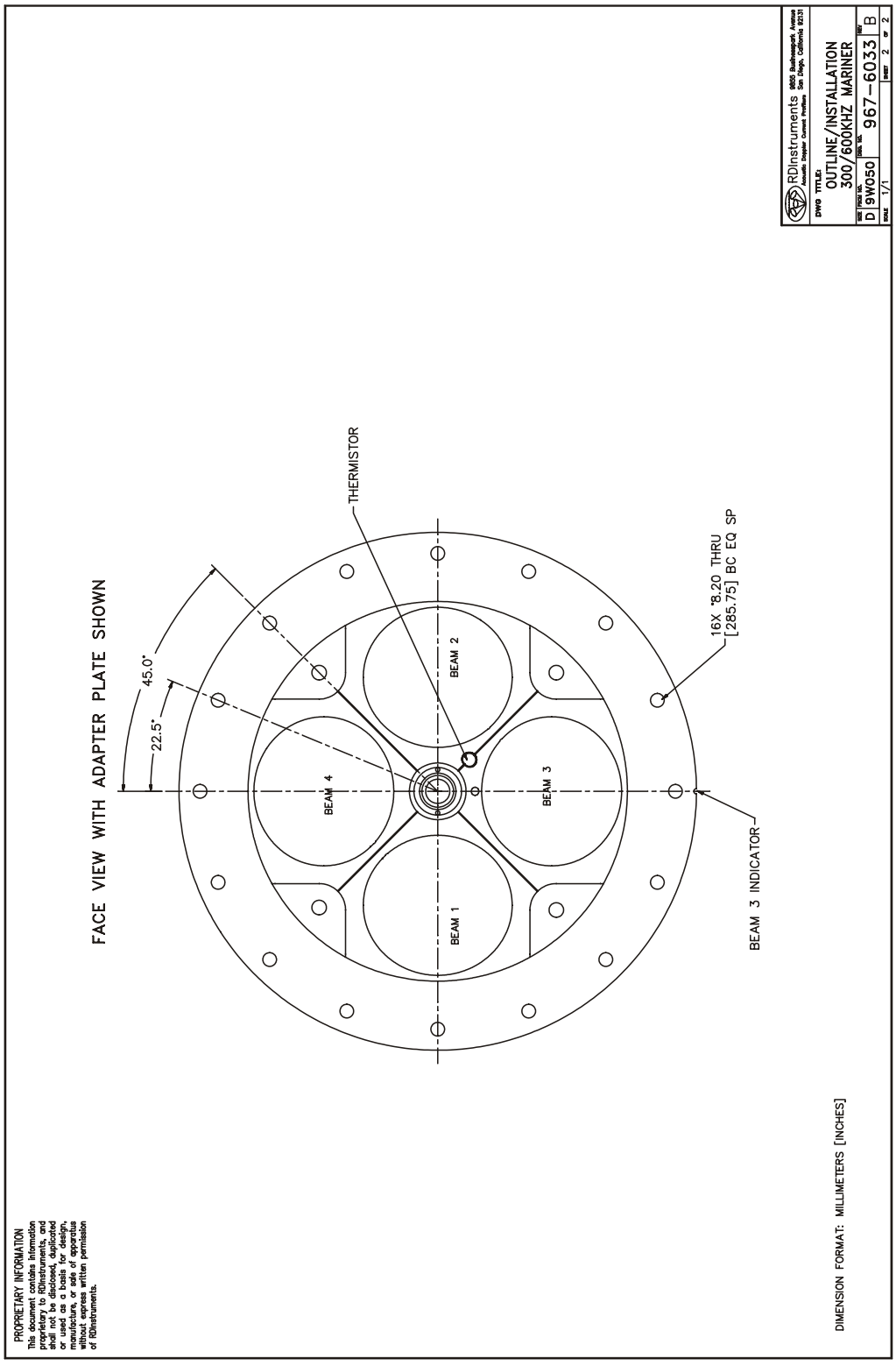

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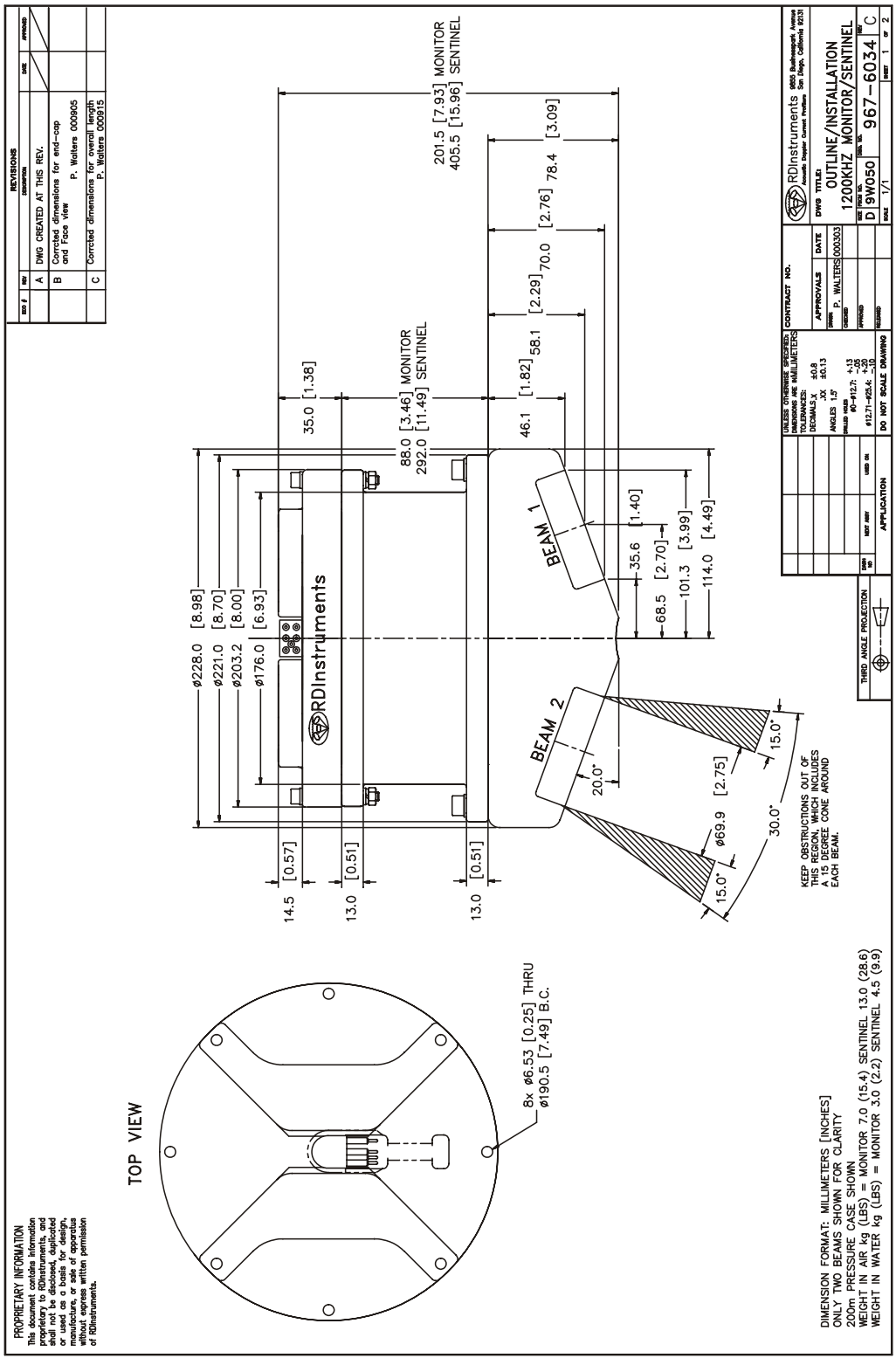
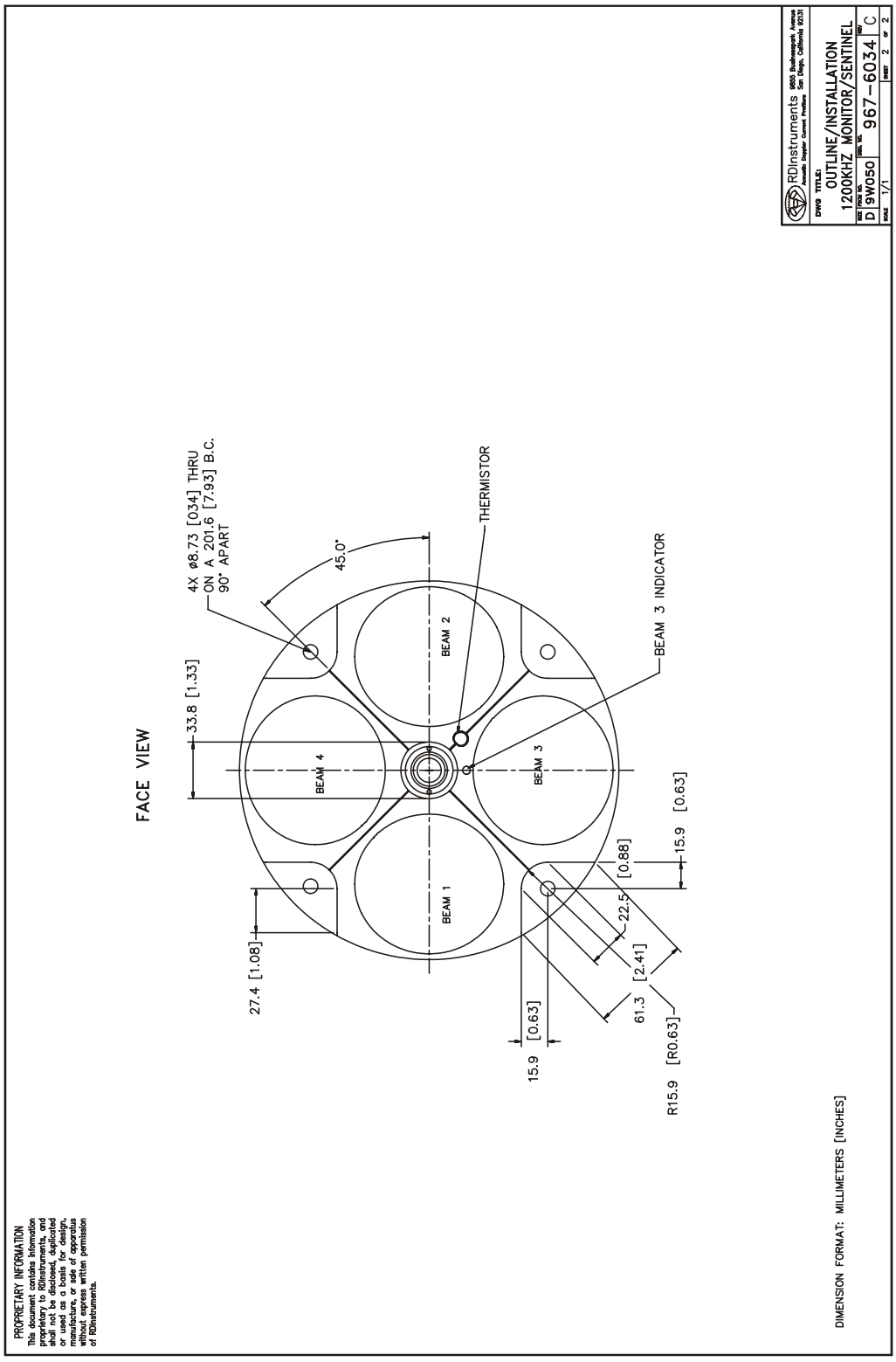
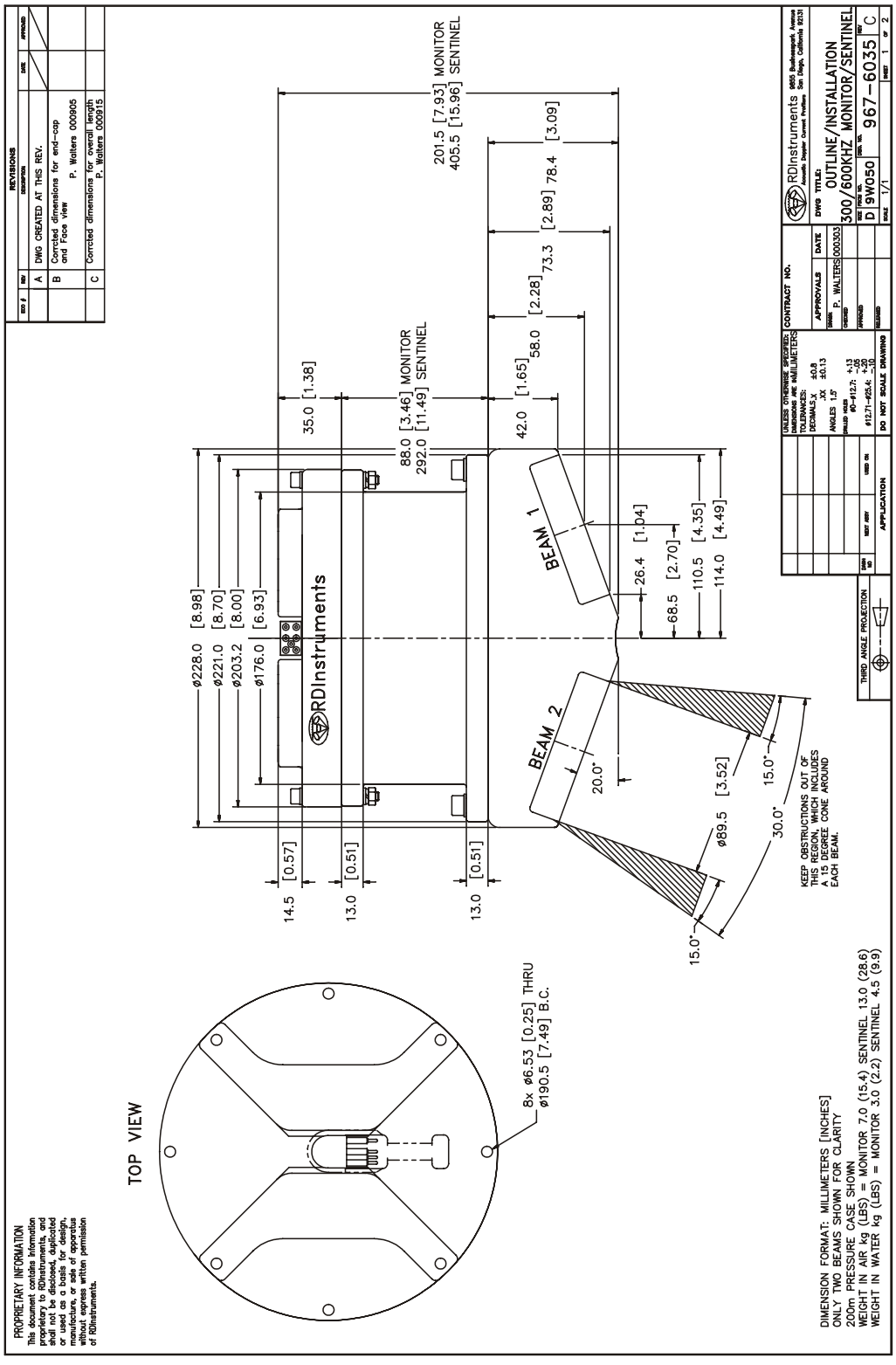


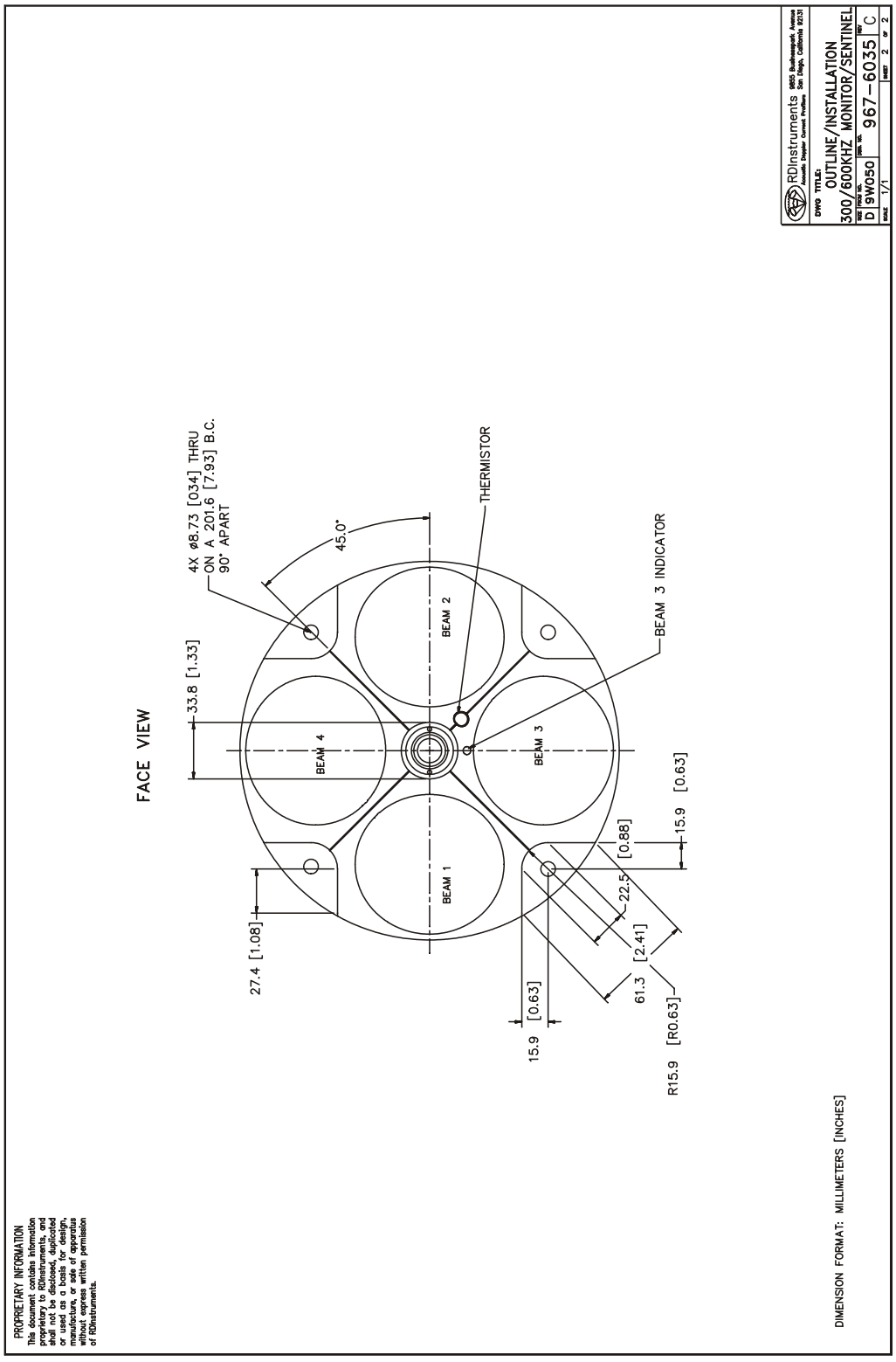
967-6034 Sheet 2



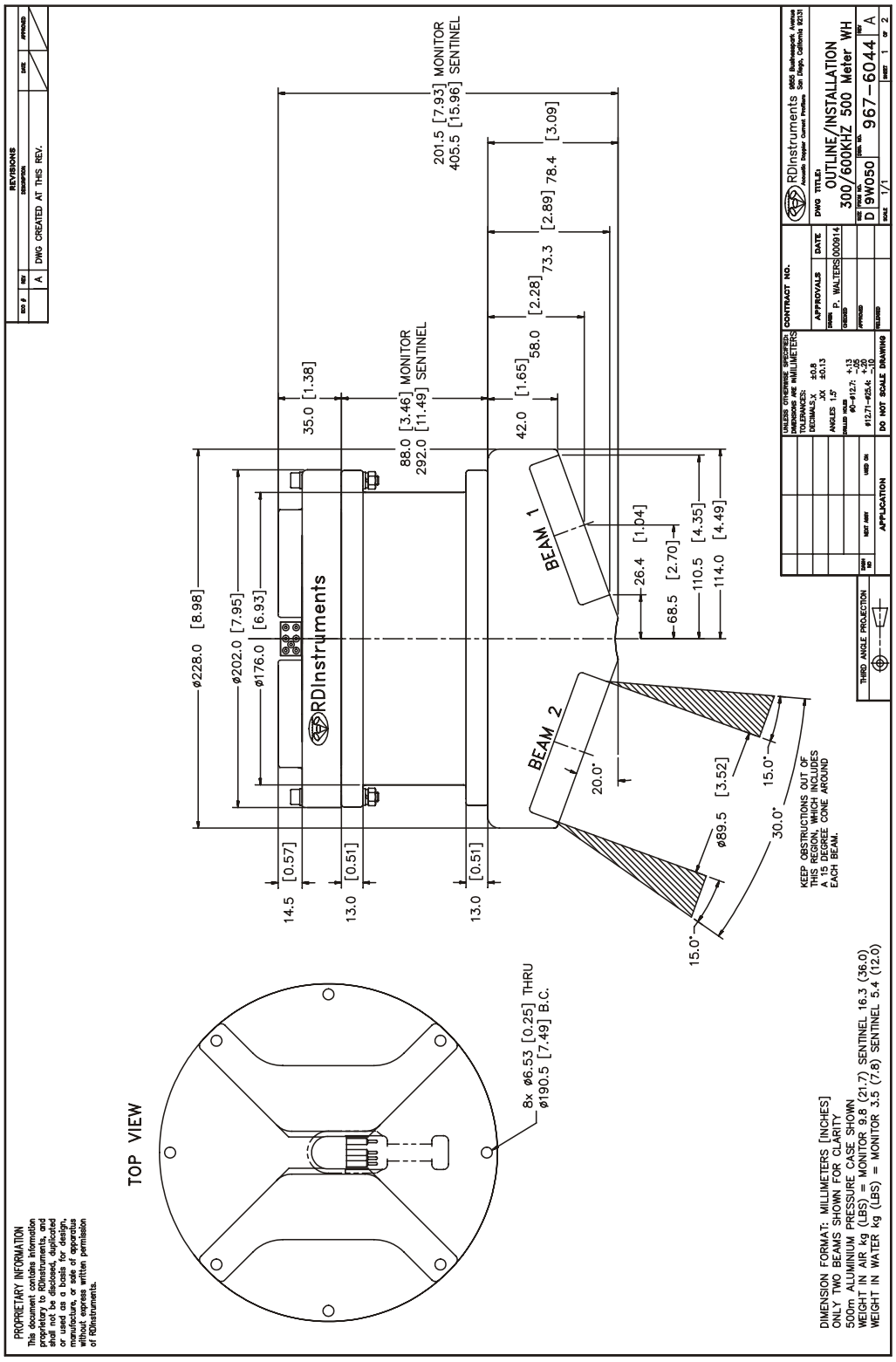
967-6035 Sheet 1



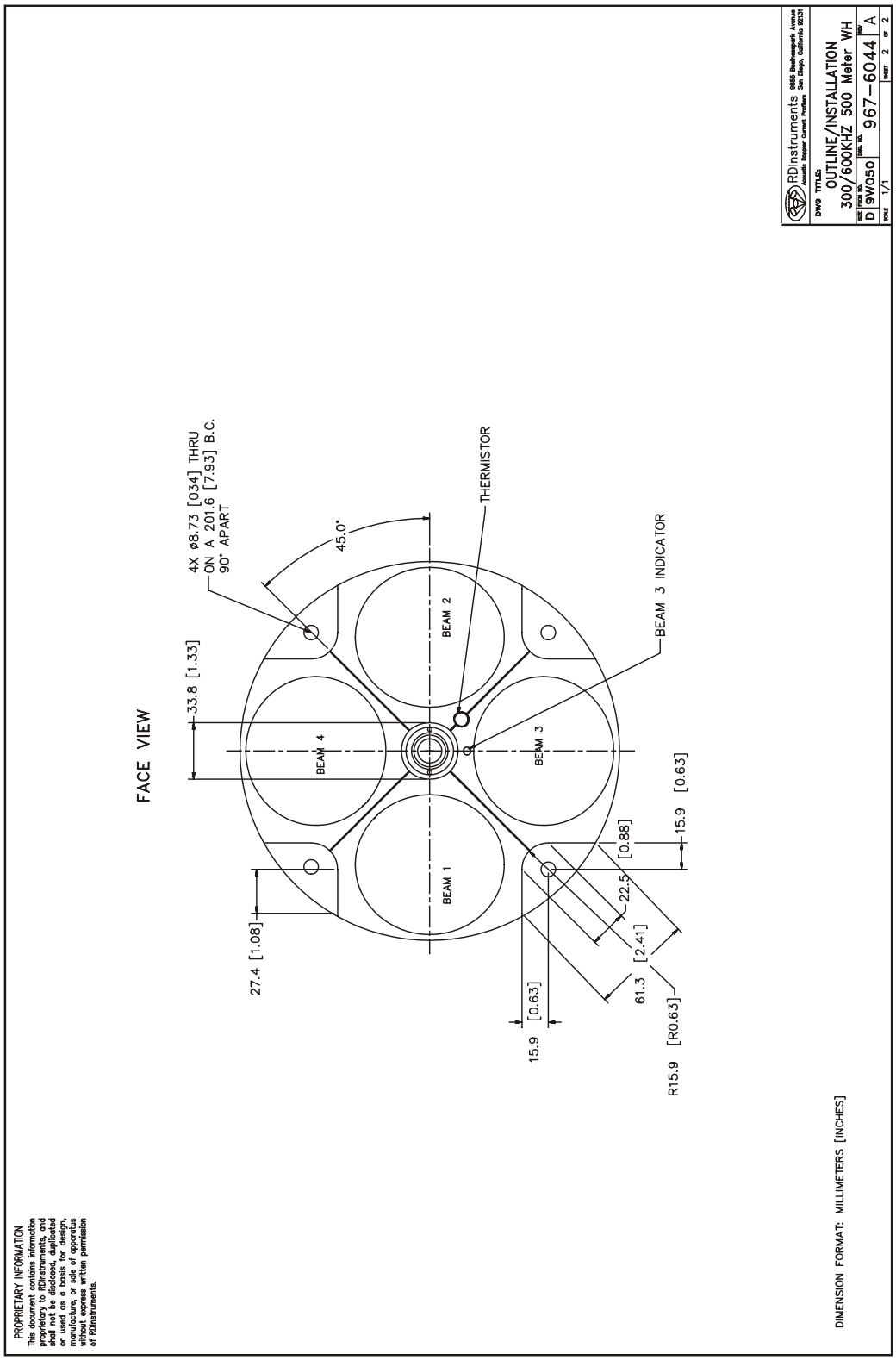
967-6035 Sheet 2



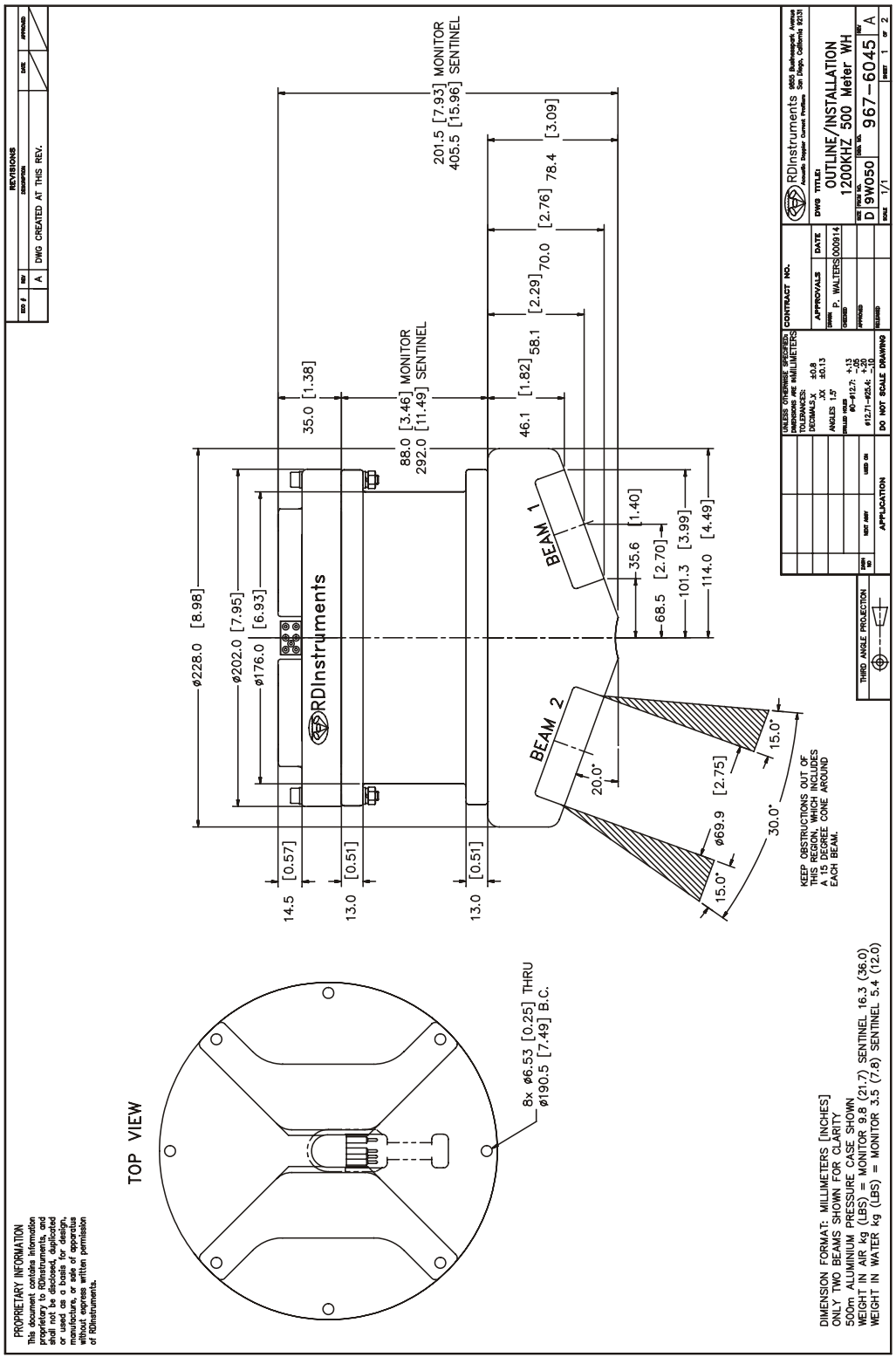
967-6044 Sheet 1



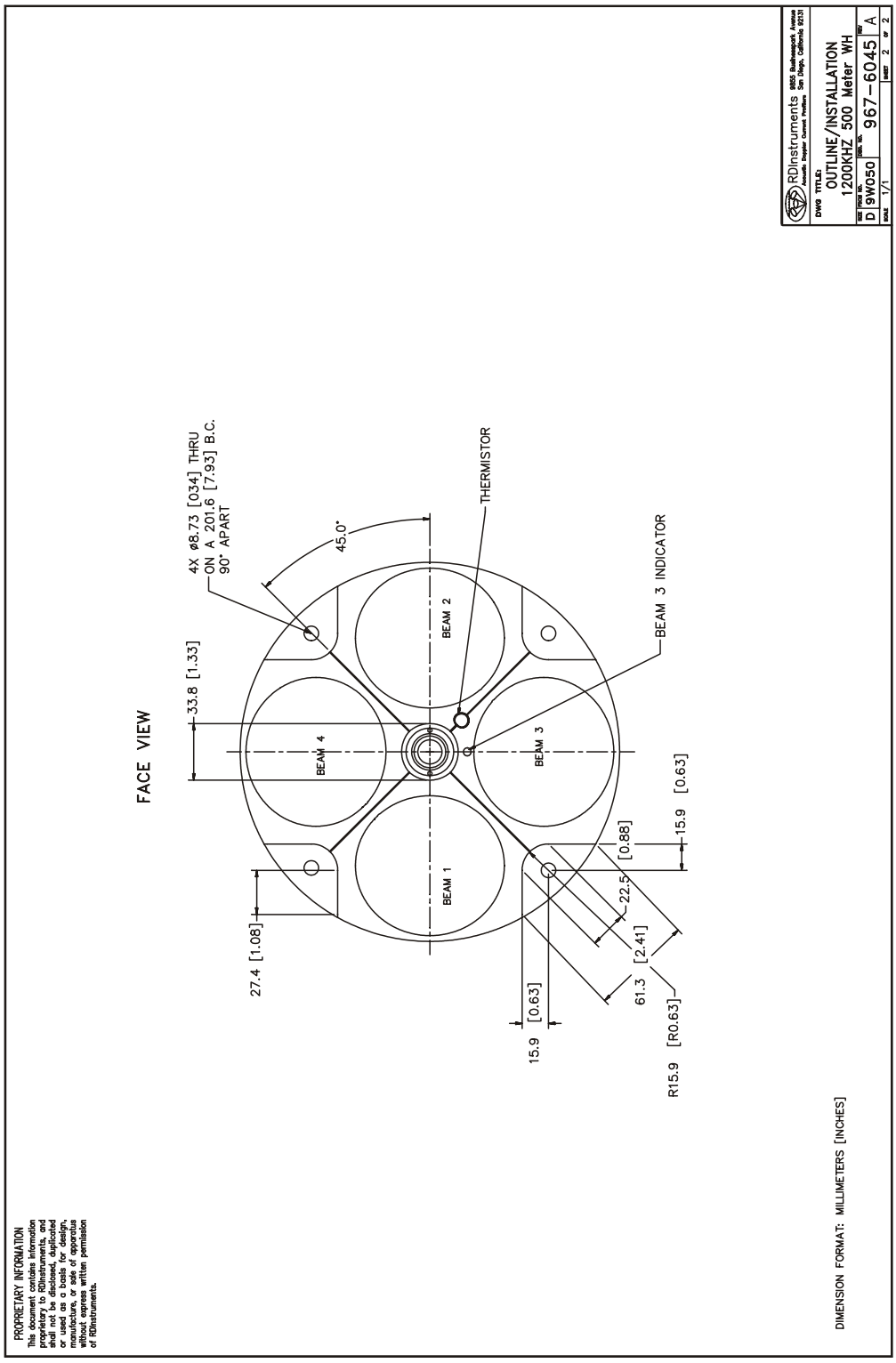
967-6044 Sheet 2



967-6045 Sheet 1



967-6045 Sheet 2



9 Glossary

If, after reviewing this section, you are unable to find the word/jargon in question, please **send us an e-mail** containing that word. Your questions will ensure that our glossary remains an effective reference tool for our customers.

------ *A* ------

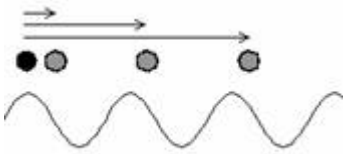
Acoustic Doppler Current Profiler (ADCP): An instrument that obtains profiles of water velocity by transmitting sound of known frequency into the water and measuring the Doppler shift of reflections from scatterers, which are assumed to be passively moving with the water.

Acoustic Window: A covering for the hull-side opening of a sea chest that is transparent to sound. A vessel mounted ADCP is typically mounted in a sea chest and the acoustic window helps to isolate it from biofouling organisms and also the flow noise generated by the vessel.

ADCP: Acoustic Doppler Current Profiler

ADCP Coordinates: Profile data is reported in an orthogonal coordinate system as referenced to the instrument. Beam 3 is forward. Sideways is to the right of forward (beam 2 for a down-looking ADCP, beam 1 for an up-looking ADCP).

Ambiguity: ADCPs determine the radial motion between a source and scatterer by measuring the phase change of the reflected signal. Because phase is periodic, this solution is multi-valued. For example, all three of the displacements shown below will return the same phase measurement, which results in ambiguity:



Ambiguity Resolution: A method to count the number of wavelengths included between two points where phase is measured, thereby removing the ambiguity associated with measuring only phase.

Ambiguity Velocity: The maximum allowable radial motion for phase measurements to be unambiguous, corresponding to a maximum observable velocity, beyond which ambiguity resolution is required.

Autonomous Underwater Vehicle (AUV): An unmanned submersible with propulsion, generally capable of navigation and accomplishing specific tasks (such as data gathering).

AUV: Autonomous Underwater Vehicle

------ B ------

Backscatter: 1) The portion of a sound wave that is reflected by scatterers directly back toward the source. 2) A qualitative measurement (in decibels) of scatterer concentration which is calculated in the WinRiver software. This calculation corrects the echo intensity data for sound absorption, beam spreading, transducer temperature, etc. and provides an excellent means of tracking relative concentration (e.g. "Is most of the sediment in the water here or is it there?"). Obtaining a quantitative measurement (e.g. "How many mg/L of bottom sediment are in this parcel of water?") requires a field calibration at the measurement site. There is a third-party software package, *Sediview*, designed for this task.

BBBatch: Utility program to allow automated conversion of a series of raw binary ADCP files to ASCII files.

BBCheck: Utility program that checks the integrity and quality of raw binary ADCP files.

BBConv: Utility program to convert some portion of a raw binary ADCP file into an ASCII file using a decoder file. Several decoder files are included on the RDI Tools CD, for example: extract only distance to first bin, extract only navigation data, etc. Complete documentation on these decoder files as well as information on how to write your own is available.

BBList: Utility program for viewing and converting raw binary ADCP data files. It is a menu-driven program offering a step-by-step process to convert raw binary files to ASCII files.

BBMerge: Utility program to convert comma-delimited ASCII files back into raw binary ADCP format.

BBSlice: A raw data sub-sectioning utility program. BBSlice converts a raw data file into a series of ASCII files, opening a new ASCII file whenever there is a jump in the sequence of ensemble numbers.

BBss: Utility program to calculate the speed of sound when given temperature, salinity and depth.

BBSub: A raw data sub-sectioning utility program. BBSub allows you to extract subsets of raw data from a large raw data file by choosing the starting and ending ensemble number.

BBTalk: Terminal emulator program for direct communication with the CPU of an ADCP or DVL.

Beam Angle: The angle between a transducer beam's main axis and the vertical axis of the ADCP or DVL (typically 20 or 30º).

Beam Coordinates: Profile data is reported as referenced along each beam (i.e. no coordinate transformation is performed upon the raw data).

Beam Spreading: The extent to which the main lobe of energy generated by a transducer fans out, or spreads as an acoustic wave front, with distance from the transducer. This is proportional to λ/d where λ is the wavelength of sound generated and d is the diameter of the transducer. Note: this is why ADCP transducer diameter increases with decreasing operating frequency (and increasing wavelength).

Bin (Depth Cell): A measurement within a profile, generally equivalent to a single-point current meter on a mooring.

Bin Mapping (Depth Cell Mapping): When the ADCP is tilted; the measurements taken at equal distances along each beam are no longer in the same horizontal layer of water. For example, in the image below the tilted ADCP bins do not line up horizontally, they are offset by one bin. In this case the tilted ADCP will offset the bins on the "right" beam by one bin in order to line them up horizontally with the bins on the "left" beam before combining the measurements to compute the velocity.

Blank Zone: The area near the head of an ADCP in which no measurements are taken. This is usually the minimum distance required to avoid collecting data that is potentially contaminated by ringing, but is sometimes extended for other reasons (e.g. to begin measurement well beyond the flow influence of a mounting structure).

Bottom Discharge: When using an ADCP to measure river discharge, it is not possible to measure all the way to the bottom (due to sidelobe contamination and the finite resolution of the depth cells). In order to get an accurate approximation of the total discharge, the flow in this area must be estimated and included, usually by extrapolating the measured velocities to the bottom using a power curve fit.

Bottom Track: In moving platform applications where the bottom is within range of the ADCP or DVL, a special ping can be transmitted to measure the Doppler shift of the signal return from the bottom. If the bottom is not moving, this measurement is a very accurate measurement of the platform velocity. For ADCPs this velocity is typically used to extract the true water velocity profile from the measured velocity profile (by removing the vehicle motion from the measurements). For DVLs, this IS the desired velocity.

Bottom Track Modes: There are currently four bottom tracking modes of operation available from TRDI:

Bottom Mode 4: Uses ambiguity resolution, and adjusts lags for reduced variance at higher elevations (or deeper depths).

Bottom Mode 5: Specifically designed for reduced variance in shallow water/low elevations. It transmits several pings with computations to best determine depth and speed. This mode is the default mode, but it will automatically switch to Bottom Mode 4 if conditions warrant.

Bottom Mode 6: Offers special narrow bandwidth operation to reduce the potential for interference or for stealth. No ambiguity resolution, instead bottom mode 6 requires user input of an approximate operating elevation (or depth).

Bottom Mode 7: Similar to bottom mode 5, except that it is optimized for slow-moving platforms in very shallow, high backscatter environments.

Break: A wake up command to an ADCP or DVL that places the instrument in command mode.

Broadband ADCP: An ADCP that uses broadband processing.

Broadband Processing: Use of coded pulses to make multiple measurements of phase with a single ping, and thereby greatly increase the precision of the measurement.

------ C ------

Channel Master: Model name for an ADCP designed to use horizontal profiling for flow monitoring in inland waterways.

Command Mode: The state into which an ADCP or DVL goes upon receiving a break. In this mode the ADCP or DVL is waiting to receive a command. It draws relatively high power, so the ADCP or DVL will go to sleep if no command is received for five minutes.

Correlation: A key quality control parameter, this is essentially a measurement of how much the particle distribution has changed between phase measurements. The less the distribution has changed, the higher the correlation, and the more precise the velocity measurement.

------ D ------

Dead Reckoning: A navigation method where position is estimated by measuring velocity, heading and time from the last known position.

Degaussing: Technique used to remove the magnetic field from TRDI battery packs before installation, done to minimize any effects the batteries will have on the magnetic compass.

Depth Cell (Bin): A measurement within a profile, generally equivalent to a single-point current meter on a mooring.

Depth Cell Mapping (Bin Mapping): When the ADCP is tilted; the measurements taken at equal distances along each beam are no longer in the same horizontal layer of water. For example, in the image below the tilted ADCP bins do not line up horizontally, they are offset by one bin. In this case the tilted ADCP will offset the bins on the "right" beam by one bin in order to line them up horizontally with the bins on the "left" beam before combining the measurements to compute the velocity.

DGPS: Differential Global Positioning System

Differential Global Positioning System (DGPS): Satellite-based navigation aid for precise measurement of location. When the bottom is out of range or moving, calculating the distance between DGPS position fixes and dividing by the time between those fixes can be used to measure the platform velocity.

Direct-Reading ADCP: An ADCP intended for real-time operation. Direct-Reading ADCPs do not have internal batteries or an internal recorder.

Discharge: The total flow through a section of a river. Rio Grande ADCPs obtain discharge measurements by transecting the river to measure water velocities, boat velocity, and the cross sectional area of the river and combining these measurements with estimates for the flow in the areas that can not be measured (edge estimates, bottom discharge and top discharge).

Distance Made Good: When measuring transects of data with a moving platform, this is a measure of the actual distance between the platform and the start point (i.e. variations in course track are removed).

Doppler Shift: Named for Johann Doppler (1803-1853), the German physicist who first predicted it: it is the shift in frequency caused by radial motion between a source and an observer. Specifically, $f_D = f_S (v/c)$: Where D is the Doppler-shifted frequency, f_S is the source frequency, v is the relative velocity between source and observer, and c is the speed of sound.

Doppler Velocity Log (DVL): An instrument designed to measure the velocity and elevation of a moving platform with bottom tracking. Most DVLs will switch to measuring velocity relative to the water when the bottom is out of range.

DVL: Doppler Velocity Log.

------ E ------

Earth Coordinates: Profile data is reported in an orthogonal coordinate frame as referenced to the Earth (East, North and Up). "North" can mean magnetic or true, depending on the heading input.

Echo Intensity: A key quality control parameter, echo intensity is a measure of the signal strength intensity returned to the transducer. High echo intensity can show solid targets (e.g. a boundary, obstruction or fish), while low echo intensity can show insufficient scatterers or the limits of profiling range for the environment.

Edge Estimate: When measuring river discharge with an ADCP it is not possible to measure to zero depth at the banks of the river. The flow through this unmeasured area must be approximated in order to obtain an accurate estimate of the total discharge.

Ensemble: A group of measurements (pings) considered together. An ensemble is usually the average of the individual measurements, and has a higher precision than any individual measurement.

Error Velocity: A key quality control parameter that derives from the four beam geometry of an ADCP. Each pair of opposing beams provides one measurement of the vertical velocity and one component of the horizontal velocity, so there are actually two independent measurements of vertical velocity that can be compared. If the flow field is homogeneous, the difference between these vertical velocities will average to zero. To put the error velocity on a more intuitive footing, it is scaled to be comparable to the variance in the horizontal velocity. In a nutshell, the error velocity can be treated as an indication of the standard deviation of the horizontal velocity measurements.

------ F ------

Fish Detection Threshold: Used to identify and mark as bad any velocity measurement that was potentially contaminated by a fish (because fish are generally not passively following the flow). It is a flag on the maximum allowable value for the measured echo intensity return.

Frequency: The number of wave crests passing a given point per unit time.

------ G ------

Gimbals: Frame that will support the weight of an object but allow its free rotation. Gimbals can be constructed to allow free rotation in one, two, or three axes.

GO-DVL: DOS batch file used to configure a Navigator and start data collection with *Shiptrack*.

Gyro: A rapidly spinning device mounted on gimbals to maintain a constant orientation. These devices are commonly used to measure heading on ships because, unlike magnetic compasses, they are unaffected by ferrous metals or by varying electromagnetic fields. They can also be used to measure pitch and roll because, unlike liquid level sensors, they are unaffected by accelerations.

------ H ------

Homogeneity: The extent to which the current measured by all four beams is the same. A key assumption of all ADCP processing is that the currents are horizontally homogeneous across the four beams. This assumption is checked for each measurement by using the error velocity measurement.

Horizontal ADCP (H-ADCP): Instrument designed to measure velocity profiles in a horizontal plane.

------ I ------

Inertial Navigation: Method for estimating the attitude and position of a moving platform (of primary interest here are AUVs) by integrating measurements from gyros and accelerometers. This integration is subject to large errors over time, so DVLs and pressure sensors are commonly incorporated as external inputs to measure and correct these errors.

------ J ------

------ K ------

------ L ------

Lag: A time delay between pulses or pings.

WorkHorse: Model name for Workhorse ADCPs of frequency 75 kHz.

Lowered ADCP (L-ADCP): Technique whereby one or two ADCPs are lowered through the water column (typically on a rosette) to obtain velocity profiles over the full ocean depth. Note that a whole body of research exists on how to properly remove the motion of the rosette from the velocity measurements obtained in this manner.

------ M ------

Main Lobe: The main focus of energy emitted from a transducer. If the transducer were a flashlight, the main lobe would be the visible beam of light.

Mariner: Model name for a Workhorse Monitor ADCP configured for underway current measurement in shallow water (as opposed to the deep water Ocean Surveyor systems).

Modes: TRDI offers several modes of operation that are optimized for certain conditions. There are currently five modes of operation for water profiling available from TRDI:

Mode 1: General purpose water profiling. This is the most robust profiling mode, designed for the widest variety of measurement applications. Mode 1 can resolve high velocities and can measure over long ranges.

Mode 5: For high resolution profiling in shallow water with low flows. Mode 5 should be used with bottom tracking. It offers the lowest standard deviation per measurement, but is also the most limited in its allowed performance envelope (e.g. low velocity flow, slow platform movement, no high shears or turbulence).

Mode 8: Also for high resolution profiling in shallow water. Mode 8 should also be used with bottom tracking. It has higher standard deviation per measurement than mode 5, but allows a somewhat wider performance envelope.

Mode 11: The latest in our high resolution profiling modes. Intended for the shallowest water, it is also well suited for boundary layer studies. Mode 11 should be used with bottom tracking. It allows smaller depth cells (1 cm), more depth cells, and has improved signal processing which allows faster ping rates and a wider performance envelope than modes 5 and 8. Mode 11 is intended to supercede mode 5.

Mode 12: Offers increased resolution (1 cm depth cells) and uses multiple sub-pings to improve the standard deviation of each measurement. Mode 12 allows measurement of fast moving, shallow water; and can also be used to improve the standard deviations of any measurement (any range, any velocity) when the ADCP heading is fixed or reasonably steady.

Monitor: Model name for a direct reading Workhorse ADCP.

Moving Bottom: Some rivers carry such a heavy sediment load that they do not have a clearly identifiable bottom. In essence, the mud just keeps getting thicker and slower with depth. In such environments it is not un-

common for bottom tracking measurements to lock onto a sediment layer that is still moving, resulting in a bias to the bottom tracking velocity. This is especially important for river discharge measurements, where the vessel's navigation must be substituted for the bottom track velocity to obtain accurate results.

------ N ------

Navigator: Model name for the TRDI Doppler Velocity Log.

Narrowband ADCP: An ADCP that uses narrowband processing.

Narrowband Processing: Uses a single pulse per ping to measure velocity. The lack of coding in the pulse makes a narrowband measurement much less precise, but it allows profiling over a longer range. Narrowband processing generally requires much larger ensembles to get a precise measurement.

------ O ------

Ocean Observer: Low frequency Phased Array ADCP for cabled deployment, usually from an oilrig.

Ocean Surveyor: Low frequency Phased Array ADCP for vessel-mounted operations.

------ P ------

Percent Good: A key quality control parameter, percent good indicates what fraction of the pings passed the various error thresholds. Each depth cell reports four values for percent good, and the meaning depends on the coordinate frame. If data is collected in beam coordinates, then the four percent good values represent the percentage of the pings collected by each beam for that depth cell whose correlation exceeded a low correlation threshold. In the other coordinate frames (ADCP, Ship and Earth Coordinates), the four Percent Good values represent (in order): 1) The percentage of good three beam solutions (one beam rejected); 2) The percentage of good transformations (error velocity threshold not exceeded); 3) The percentage of measurements where more than one beam was bad; and 4) The percentage of measurements with four beam solutions.

Phase: An engineering measure of the propagation delay caused by radial motion between scatterer and source. Phase is ambiguous in that it is cyclical (e.g. 10 º is the same phase as 370 º).

Phased Array Transducer: A single, flat, multi-element transducer that uses a TRDI proprietary technique to simultaneously form all four beams. Available phased array transducers are generally low frequency (38 kHz, 75 kHz and 150 kHz) long range devices.

Ping: The entirety of the sound generated by an ADCP transducer for a single measurement cycle. A broadband ping contains a coded series of pulses and lags, while a narrowband ping contains a single pulse.

Ping Mode: Power conserving mode for a deployed ADCP or DVL, where only the power needed for the immediate deployment task is drawn (as opposed to command mode, where the ADCP consumes considerable power while simply waiting for input). This mode saves the deployment configuration so that, in the event of a power interruption, the ADCP or DVL will be able to automatically resume the configured deployment upon return of power.

PlanADCP: Windows-based software package allowing the user to configure, and evaluate the consequences of, a deployment command-set for an ADCP.

Profile: A series of regularly spaced depth cells in which the ADCP measures velocity along with several quality control parameters.

Pulse: A sound wave generated by a transducer.

Propagation Delay: The change in the travel time of sound between a source and scatterer, generally due to radial motion. As an example: if it takes longer for sound to reflect back from a scatterer than it did a short while ago (and the speed of sound has not changed), then the scatterer must be getting farther away.

------ Q ------

Quartermaster: The model name for a self-contained 150kHz Workhorse ADCP.

------ R ------

Radial Motion: Movement, which alters the distance between source and scatterer.

Range: The maximum profile length of an ADCP, it depends on several factors (note that these factors are inter-related in a complex way, and the generalizations below are intended only as rules of thumb – use PlanADCP to check specific combinations):

1. Frequency: the lower the frequency, the longer the range.
2. Depth cell size: the larger the cell, the longer the range.
3. Mode of operation: mode 1 has the longest range.
4. Bandwidth: the narrower the bandwidth, the longer the range.
5. Concentration of scatterers: generally, the more scatterers, the longer the range.

6. Temperature: generally, the colder the water, the longer the range.
7. Salinity: generally, the fresher the water, the longer the range.

Range Gating: After sending a ping into the water, the ADCP transducers listen for returned signal. The time series of the returned signal is then broken into a sequence of time segments, or range gates. Each segment is equivalent to a depth cell, with the last segment coming from the farthest range from the ADCP.

RDI Tools: Software package containing all of the BB* programs (*BBTalk*, *BBList*, etc.) as well as several commonly used decoder files.

Reference Layer: In moving platform applications where the bottom is out of range, the vessel motion can be approximated by assuming the water is motionless at some point in the measured profile. This point is the reference layer.

Remotely Operated Vehicle (ROV): unmanned submersible controlled by an operator via a tethering cable.

Ringing: After transmission the ADCP electronics, transducer and immediate surrounding equipment (particularly in vessel mounted ADCPs) all require some finite time to dampen the transmit energy, during which time any signal return from scatterers will be contaminated.

Rio Grande ADCP: The model name for an ADCP optimally configured for measurement of river discharge. A distinguishing feature of Rio Grande ADCPs is that they are designed to operate from a 12 VDC power supply (all other ADCPs operate from 20 – 60 VDC).

Rosette: Oceanographic instrumentation package found on most research vessels. Rosettes are designed to be lowered to depths of interest while collecting data of various types. Most Lowered-ADCPs are mounted on rosettes.

ROV: Remotely Operated Vehicle

------ *S* ------

Scatterers: Small particles or plankton in the water which reflect sound waves.

Sea Chest: Cavity in the hull of a vessel to allow stream-lined, recessed mounting of equipment such as a Vessel Mount ADCP.

Sediview: Third party software designed to use ADCP echo intensity measurements and *in situ* sampling to obtain quantitative estimates of sediment concentration.

Self-Contained ADCP: An ADCP equipped with internal batteries and an internal recorder for autonomous operation.

Sentinel: The model name for a self-contained Workhorse ADCP.

Ship Coordinates: Profile data is reported in an orthogonal coordinate frame as referenced to the ship (if beam 3 is forward then ship coordinates are the same as instrument coordinates).

Shiptrack: DOS program to integrate and display Navigator data.

Sidelobes: Peaks in sound intensity generated by a transducer found to the side of the main lobe.

Sidelobe Contamination: This only need be considered when operating an ADCP near a boundary (e.g. in shallow water). The beam angle of the main lobe of an ADCP transducer is 20 or 30º off the vertical, which means that the distance to the boundary along the ADCP centerline is shorter than the distance to the boundary along a beam. Because most boundaries will reflect very strongly (much more strongly than the scatterers), sidelobe energy can travel the shorter path directly to the surface and thereby include the "velocity" of the boundary with the velocity measurements taken along the beams at any longer distance. This potential for interference depends strictly on the beam angle. An ADCP with a 20º beam angle has the potential for sidelobe contamination at (distance to the boundary)*cos(20º), or equivalently, the last 6% of the profile. Note: Sidelobe contamination is not relevant for DVLs, which specifically look for the bottom.

Software Break: When using radio or acoustic telemetry, it is usually not possible to send a break signal. Under these circumstances an ADCP can be configured to recognize a series of keystrokes (i.e. = = =) as a break.

Source: Originator of sound of known frequency, here typically the transducer of an ADCP.

StreamPro: Model name for ADCP designed for discharge measurement in shallow waterways.

------ T ------

Top Discharge: When using an ADCP to measure river discharge, it is not possible to measure all the way to the surface (due to the blank zone and to the need to mount the transducers at sufficient depth to remain submerged with no air entraining past the transducers). In order to get an accurate approximation of the total discharge, the flow in this area must be estimated and included, usually by extrapolating the measured velocities to the surface.

Transducer: A device to convert electrical energy into sound waves, and vice versa.

------ U ------

Unmanned Underwater Vehicle (UUV): Generic term referring to both AUVs and ROVs.

UUV: Unmanned Underwater Vehicle

------ V ------

Vessel Mount: An ADCP mounted to the hull of a vessel, typically in a sea chest, and having inputs from the vessel's navigation equipment.

VM-DAS: Windows-based data acquisition package for vessel mount ADCPs. This package includes the ability to incorporate the ship's navigation equipment.

------ W ------

Wavelength: The distance between successive wave crests in a sound wave.

WinADCP: Windows-based post-processing package for ADCP data.

WinH-ADCP: Windows-based data acquisition and playback package for Horizontal ADCPs.

WinRiver: Windows-based software package for real time ADCP data gathering. It is designed primarily for measurement of river discharge and allows integration of the platform's navigation equipment. It also converts echo intensity measurements to qualitative estimates of backscatter.

WinSC: Windows-based software package for self-contained ADCPs includes configuring, testing, data recovery and viewing options.

Workhorse ADCP: The generic model name for all of the non-phased array broadband ADCPs currently produced by TRDI.

------ X ------

Xdcr: A common abbreviation for transducer.

------ Y ------

------ Z ------

ZedHed: TRDI trade name for a transducer designed to minimize ringing.

NOTES

WorkHorse

**Monitor, Sentinel, Mariner,
Quartermaster, and Long Ranger ADCPs**

Commands and Output Data Format

P/N 957-6156-00 (November 2007)

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WorkHorse Commands and Output Data Format

1 Introduction to WorkHorse Commands

This guide defines the commands used by the WorkHorse Monitor, Sentinel, Mariner, Quartermaster, and Long Ranger ADCPs. These commands (Table 2, page 8) let you set up and control the WorkHorse ADCP without using an external software program such as our *WinSC*, *Waves*, *VmDas*, and *WinRiver* programs. However, we recommend you use our software to control the WorkHorse ADCP because entering commands directly from a terminal can be difficult. *Make sure you read and understand "Using Direct Commands to Deploy your ADCP," page 6 before deploying your ADCP.* Most WorkHorse ADCP settings use factory-set values (Table 3, page 11). If you change these values without thought, you could ruin your deployment. *Be sure you know what effect each command has before using it.* Call TRDI if you do not understand the function of any command.

Using *WinSC* for self-contained deployments or *VmDas/Waves/WinRiver* for real-time deployments to develop the command file will ensure that the WorkHorse ADCP is set up correctly. The commands shown in Table 2, page 8 directly affect the range of the ADCP, the standard deviation (accuracy) of the data, and battery usage.

NOTE. This guide applies to WorkHorse Monitor, Sentinel, Mariner, Quartermaster, and Long Ranger firmware version 16.30.

When new firmware versions are released, some commands may be modified, added, or removed. Read the README file on the upgrade disk. When an addition or correction to this manual is needed, an Interim Change Notice (ICN) will be posted to our web site. Please check our TRDI's web site often at www.rdinstruments.com.

1.1 Data Communication and Command Format

You can enter commands with an IBM-compatible computer running TRDI's *BBTalk*. The WorkHorse ADCP communicates with the computer through an RS-232 (or RS-422) serial interface. We initially set the WorkHorse ADCP at the factory to communicate at 9600 baud, no parity, and one stop bit.

Immediately after you apply power to the WorkHorse ADCP, it enters the STANDBY mode. Send a BREAK signal using *BBTalk* by pressing the **End** key to put the ADCP in command mode. When the WorkHorse ADCP receives a BREAK signal, it responds with a wake-up message similar to the one shown below. The WorkHorse ADCP is now ready to accept commands at the ">" prompt from either a terminal or computer program.

```
[Break Wakeup A]
WorkHorse Broadband ADCP Version 16.xx
Teledyne RD Instruments (c) 1996-2005
All rights reserved.
>
```

NOTE. If you use a terminal/program other than *BBTalk*, the BREAK length (up to down transition) must last at least 300 ms.

1.1.1 Command Input Processing

Input commands set WorkHorse ADCP operating parameters, start data collection, run built-in tests (BIT), and asks for output data. All commands are ASCII character(s) and must end with a carriage return (CR). For example,

```
>WP1<CR> [Your input]
```

NOTE. Leading zeros are not required. Sending WP1 and WP00001 are the equivalent.

If the entered command is valid, the WorkHorse ADCP executes the command. If the command is one that does not provide output data, the WorkHorse ADCP sends a carriage return line feed <CR> <LF> and displays a new ">" prompt. Continuing the example,

```
>WP1<CR>      [Your original input]
>             [WorkHorse ADCP response to a valid, no-output command]
```

If you enter a valid command that produces output data, the WorkHorse ADCP executes the command, displays the output data, and then redisplays the ">" prompt. Some examples of commands that produce output data are ? (help menus), CS (start pinging), PS (system configuration data), and PA (run built-in tests).

If the command is not valid, the WorkHorse ADCP responds with an error message similar to the following.

```
>WPA<CR>                                          [Your input]
>WPA  ERR 002:  NUMBER EXPECTED<CR><LF>          [WorkHorse ADCP response]
>
```

After correctly entering all the commands for your application, you would send the CS-command to put the ADCP into the ping mode and begin the data collection cycle.

1.1.2 Data Output Processing

After the WorkHorse ADCP completes a data collection cycle, it sends a block of data called a *data ensemble*. A data ensemble consists of the data collected and averaged during the ensemble interval (see TE-command). A data ensemble can contain header, leader, velocity, correlation magnitude, echo intensity, percent good, and status data.

WorkHorse ADCP output data can be in either hexadecimal-ASCII (Hex-ASCII) or binary format (set by CF-command). The Hex-ASCII mode is useful when you use a terminal to communicate with, and view data from the WorkHorse ADCP. The binary mode is useful for high-speed communication with a computer program. You would not use the binary mode to view data on a terminal because the terminal could interpret some binary data as control codes.

NOTE. All of Teledyne RD Instruments' software supports binary PD0 Output Data Format only.

When data collection begins, the WorkHorse ADCP uses the settings last entered (user settings) or the factory-default settings. The same settings are used for the entire deployment.

The WorkHorse ADCP automatically stores the last set of commands used in RAM. The WorkHorse ADCP will continue to be configured from RAM until it receives a CR-command or until the RAM loses its backup power. If the WorkHorse ADCP receives a CR0 it will load into RAM the command set you last stored in non-volatile memory (semi-permanent user settings) through the CK-command. If the WorkHorse ADCP receives a CR1, it will load into RAM the factory default command set stored in ROM (permanent or factory settings).

1.2 Firmware Updates

The firmware for WorkHorse ADCPs is located on flash memory chips on the CPU board. New firmware must be downloaded. To download new firmware, do the following steps.

NOTE. The CPU board must have EEPROM Parts installed to install version 16.xx or higher firmware. The firmware upgrade program checks if the ADCP is capable of upgrading to the new version of firmware.

a. Set up the WorkHorse ADCP as shown in the appropriate ADCP User's Guide.

b. Start the program WH*x*.exe (where *x* = the firmware version). Click **Setup**.

Figure 1. Firmware Update

c. Click the **View README.TXT** button to view the Readme.txt file for details on what is new in this version of firmware.

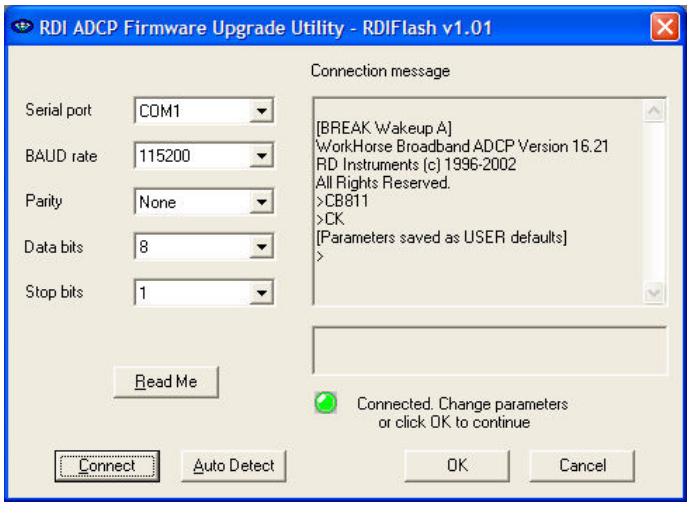


Figure 2. RDIFlash Firmware Upgrade Utility Screen

d. Click **Next** and follow the on-screen prompts.

e. If you are not able to install the new version of firmware, contact Customer Service for assistance.

f. After successfully upgrading the firmware, use *BBTalk* to test the ADCP.

1.3 Feature Upgrades

The feature upgrade installation program is used to install Bottom Tracking, Shallow Water Bottom Mode, Lowered ADCP (LADCP), High-Resolution Water-Profiling mode, High Ping Rate, and Waves capabilities in a Work-Horse ADCP.

NOTE. The upgrade disk is specific to the unit for which it was ordered. DO NOT attempt to install this feature for any other unit.

NOTE. Many feature upgrades require the latest firmware version to be installed in your ADCP. If you need to update the firmware, do this before installing the feature upgrade (see "Firmware Updates," page 4).

NOTE. Shallow Water Bottom Track Mode 7 can only be installed on 1200kHz systems.

a. Set up the WorkHorse ADCP as shown in the appropriate ADCP User's Guide.

b. Place the feature upgrade disk in the disk drive (usually the "A" drive).

c. Click the Windows **Start** button, and then select **Run**.

d. In the **Open** box, type A:*xxx*.exe, where *xxx* is the ADCP's CPU serial number. The installation program will start (see Figure 3). The program is encoded with the ADCP's serial number and the requested feature upgrade.

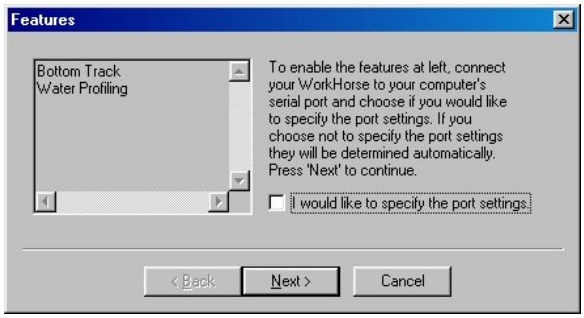


Figure 3. Installing Feature Upgrades

e. To select the port settings, select the **I would like to specify the port setting** box and click **Next**.

f. Select the **Serial Port** and **Baud Rate**.

g. Click **Next** to install the feature upgrade. Click **Finish** to exit the program.

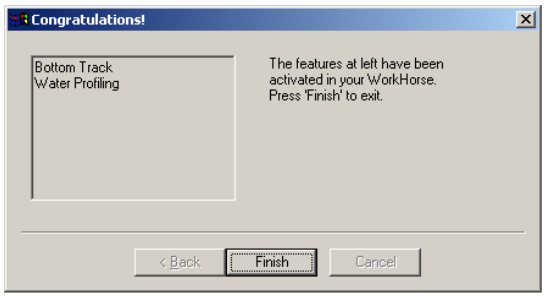


Figure 4. Feature Upgrade Completed

h. Start *BBTalk* and use the OL command (see "OL - Features," page 16) to verify the feature upgrade has been installed.

For reference, a standard WorkHorse Monitor/Sentinel ADCP includes Water Profiling. The system can be upgraded to include Bottom Track, Shallow Water Bottom Mode, Lowered ADCP (LADCP), High-Resolution Water-Profiling modes, High Ping Rate, and Waves.

NOTE. The Lowered ADCP feature can not co-exist with other feature upgrades.

A standard Long Ranger ADCP includes Water Profiling. The Long Ranger ADCP can be upgraded to include Lowered ADCP (LADCP), High-Resolution Water-Profiling modes, High Ping Rate, and Waves. Bottom Track and Shallow Water Bottom Mode, are NOT available for Long Ranger ADCPs.

NOTE. Contact your local sales representative if you are interested in upgrading your system.

1.4 Using Direct Commands to Deploy your ADCP

TRDI recommends that you use our software programs *WinSC*, *VmDas*, or *WinRiver*, etc. as your primary method of deployment. If this is not possible in your deployment then we ***strongly recommend*** that the commands shown in Table 1, page 7 be the ***minimum*** commands you send to the instrument.

CAUTION. TRDI does not recommend the use of direct commands as your primary way of deploying ADCPs as **any incorrect command setting can have severe consequences to your data collection**.

Table 1: ADCP Minimum Required Commands for Deployments

Command	Description
CR1	This command will set your ADCP to a known factory default setting and **must be your first command**
	Special WM commands here –**after CR1 command and before any other commands**
CFxxxxx	This command will set your ADCP collection mode; binary, recorder, etc.
EAxxxxx	This command will set your magnetic compass offset for true north
EDxxx	This command will set your ADCP depth
ESxx	This command will set your ADCP's expected salinity
EXxxxxx	This command will set your ADCP's coordinate system; earth, beam, etc.
EZxxxxxxx	This command will set what sensors will be used by your ADCP; heading, pitch, roll, temp, etc.
WBx	This command will set the water profile bandwidth between wide (0) and narrow (1)
WNxx	This command will set the number of depth cells to collect
WPxx	This command will set the number of pings to average
WSxxxx	This command will set the depth cell size to use
TExxxxxxxx	This command will set the time between ensembles
TPxxxxxx	This command will set the time between pings
CK	This command will save your setup to the internal RAM and **must be your second to last command**
CS	This command will start your deployment and **must be your last command**

CAUTION. Although these are our recommended minimum commands, **they may not be the only commands you need for your deployment to be successful!**

CAUTION. When the WM1 or WM15 command is used in a command file, place it after the CR1 command and before any other commands to eliminate the risk of changing a previously sent parameter. For more information, see "WM - Profiling Mode," page 94.

For example, when the ADCP receives the WM15 command, the ADCP automatically changes several commands to LADCP appropriate values. It changes the water profile bandwidth to 6 % by setting WB and LW to 1, the number of water profile pings to 1 by setting WP and LP to 1, and the time per ensemble and time per ping to 1 second by setting TE 00:00:01.00 and TP 00:01.00 respectively.

Conversely, when the ADCP has been using WM15 and receives the WM1 command, the ADCP automatically changes the same command parameters to their factory default values (see Table 3, page 11 to view the WorkHorse ADCP factory defaults).

CAUTION. When the ADCP receives a WM1 or WM15 command, *the automatic command changes are transparent to the user*, who may require other bandwidth, number of pings, time per ensemble, and/or ping values.

NOTE. Your deployment may require additional commands and these commands can be sent after the CR1 and any special WM commands but must be placed before the CK command.

1.5 Command Summary

Table 2 gives a summary of the WorkHorse ADCP input commands, their format, and a brief description of the parameters they control. Table 3, page 11 lists the factory default command settings.

NOTE. This table shows all commands including optional feature upgrades and expert commands. To see the expert commands, you must first send the command EXPERTON. **Some commands may not be available for your ADCP.**

NOTE. When newer firmware versions are released, some commands may be modified or added. Read the README file on the upgrade disk or check TRDI's web site for the latest changes.

Table 2: WorkHorse ADCP Input Command Summary

Command	Description
?	Shows command menu (deploy or system)
<BREAK> End	Interrupts or wakes up WorkHorse ADCP and loads last settings used
EXPERTON	Turns expert mode on. All commands will be listed
EXPERTOFF	Turns expert mode off.
OL	List features/special firmware upgrades that are installed
AC	Output calibration data
AD	Display factory calibration
AF	Field calibrate compass to remove hard iron error
AR	Return to factory calibration
AX	Examine compass performance
AZ	Zero pressure sensor
BA*nnn*	Evaluation amplitude minimum (1 to 255 counts)
BB*nnnn*	High Bandwidth Maximum Depth (dm)
BC*nnn*	Correlation Magnitude minimum (0 to 255 counts)
BD*nnn*	Delay Before Reacquire (0 to 999 ensembles)
BE*nnnn*	Error velocity maximum (0 to 9999 mm/s)
BF*nnnnn*	Depth guess (1 to 65535 dm, 0 = automatic)
BI*nnn*	Gain switch depth (0 to 999 meters)
BJ*nnnnn*	Bottom Blank (0 to 65535 cm)
BK*n*	Water-mass Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL*mmm,nnnn,ffff*	Water mass layer parameters: Min Size (dm), Near (dm), Far (dm)
BM*n*	Bottom track mode (5 = Default, 4 = Default minus Coherent)
BP*nnn*	Bottom Track Pings per Ensemble
BR*n*	Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS	Clear distance traveled
BV aaaaa, bbb, c	Mode 7 Parameters
BX*nnnnn*	Maximum Tracking Depth (40 to 65535 dm)
BZ*nnn*	Coherent ambiguity velocity (cm/s radial)
CB*nnn*	Serial port control (baud rate/parity/stop bits)
CC nnn nnn nnn	Choose External Devices (CC000 000 001 = MicroCAT)
CD*abc def ghi*	Serial data out
CE	Retrieve Most Recent Data Ensemble
CF*nnnnn*	Flow control
CH*n*	Suppress ba*nn*er (0 = Display, 1 = Suppress)
CI*nnn*	Instrument ID (0 to 255)
CK	Keep parameters as user defaults
CLn	Sleep between Pings (0 = No, 1 = Yes)

Continued Next Page

Table 2: WorkHorse ADCP Input Command Summary (continued)

Command	Description
CM*n*	Not used.
CN*n*	Save NVRAM to recorder (0 = On, 1 = Off)
CP*n*	Polled mode (0 = Off, 1 = On)
CQ*nnn*	Transmit power (0 = Low, 1 to 255 = High)
CR*n*	Retrieve parameters (0 = User, 1 = Factory)
CS or **Tab**	Start pinging
CX*n*	Enables/disables the low latency trigger (0 = Off, 1 = On)
CY*n*	Clear error status word (0 = Clear, 1 = Display)
CZ	Power down WorkHorse ADCP
DB*x,y,z*	RS-485 port control
DS	Load speed of sound with SVSS sample
DWx	Current ID on RS-485 bus (0 to 31)
DX	Set SVSS to raw mode
DY	Set SVSS to real mode
DZ	Get single scan from SVSS
EA±*nnnn*	Heading alignment (-179.99 to 180.00 degrees)
EB±*nnnn*	Heading bias (-179.99 to 180.00 degrees)
EC*nnnn*	Speed of Sound (1400 to 1600 m/s)
ED*nnnn*	Transducer Depth (0 to 65535 dm)
EH*nnnn*	Heading (000.00 to 359.99 degrees)
EP±*nnnn*	Pitch (-60.00 to +60.00 degrees)
ER±*nnnn*	Roll (-60.00 to +60.00 degrees)
ES*nn*	Salinity (0 to 40)
ET±*nnnn*	Temperature (-5.00 to +40.00 degrees C)
EX*nnnn*	Coordinate Transformation (Xform:Type; Tilts; 3Bm; Map)
EZ*nnnnnn*	Sensor Source (C;D;H;P;R;S;T)
FC	Clear Fault Log
FD	Display Fault Log
HA*nnn*	Waves false target threshold (fish rejection)
HB*nn*	Number of automatically chosen bins (20 Max)
HD*nnn nnn nnn*	Waves selected data (Vel;Pres;Surf ;; ;;)
HF*nnnnn*	Waves Flow Control (Res;Res;Res;Ser;Rec)
HP*nnnn*	Number of pings per record
HRhh:mm:ss.ff	Time between wave bursts (hh:mm:ss.ff)
HS*nnn*,*nnn*,*nnn*,*nnn*,*nnn*	Bins selected for directional wave data recording
HThh:mm:ss.ff	Time between wave pings (hh:mm:ss.ff)
HV*nnn*,*nnn*,*nnn*,*nnn*,*nnn*	Bins selected for velocity spectrum data recording
LA*nnn*	False target threshold maximum (0 to 255)
LC*nnn*	Low correlation Threshold (0 to 255)
LD*nnn nnn nnn*	Data out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)
LF*nnnn*	Blank after transmit (cm)
LJ*n*	Receiver gain select (0 = Low, 1 = High)
L*N*nnn	Number of depth cells (1-128)
LP*nnnn*	Pings per Ensemble (0 to 16384)
LS*nnnn*	Depth Cell Size (cm)
LV*nnn*	Ambiguity Velocity (cm/s radial)
LW*n*	Band Width Control (0 = Wide, 1 = Narrow)
LZ*aaa*,*ccc*	Amp, Corr Thresholds (0 to 255)
PA	Pre-deployment tests
PBx,y,z	PD12 bin select
PC1	Beam Continuity Built-in test
PC2	Display Heading, Pitch, Roll, and Orientation Built-in test
PD*n*	Data stream select (0 to 18)
PE*nnnn*	PD12 ensemble select (0 to 65535)
PM	Distance measurement facility
POabcd	PD12 velocity component select
PS0	Display System Configuration
PS3	Display Instrument Transformation Matrix

Table 2: WorkHorse ADCP Input Command Summary (continued)

Command	Description
PT*nnn*	Built-In test (0 to 200)
RA	Number of deployments
RB	Recorder built-in test
RDxxxxx	Create recorder file (RDOPEN, RDCLOSE)
RE ErAsE	Erase recorder
RF	Recorder free space (Bytes)
RIn	Deployment auto increment (0 = Append, 1 = New File)
RN	Set deployment name
RR	Show recorder file directory
RS	Recorder free space (Megabytes)
RY	Upload recorder files
SAxyz	Synchronize before/after ping/ensemble
SB*n*	Channel B Break Interrupt Mode (0 = Disabled, 1 = Enabled)
SI*nnnn*	Synchronization interval (0 to 65535 s)
SM*n*	RDS3 mode select (0 = Off, 1 = Master, 2 = Slave)
SS*x*	RDS3 sleep mode (0 = No Sleep, 1 = Sleep)
ST*n*	Slave timeout (0 to 10800 seconds)
SW*n*	Synchronization delay (0m to 65535 (1/10 milliseconds))
TBhh:mm:ss.ff	Time per burst
TC*nnnn*	Ensemble per burst (0 to 65535)
TEhh:mm:ss.ff	Time per ensemble (hours:minutes:seconds.100th of seconds)
TFyy/mm/dd, hh:mm:ss	Time of first ping (year/month/day, hours:minutes:seconds)
TGccyy/mm/dd, hh:mm:ss	Time of first ping (Y2k compatible) (century year/month/day, hours:minutes:seconds)
TPmm:ss.ff	Time between pings (minutes:seconds.100th of seconds)
TSyy/mm/dd, hh:mm:ss	Set real-time clock (year/month/day, hours:minutes:seconds)
TTccyy/mm/dd, hh:mm:ss	Set real-time clock (Y2k compatible) (century year /month/day, hours:minutes:seconds)
TXhh:mm:ss	Buffered Output Period (hours:minutes:seconds)
WA*nnn*	False target threshold maximum (0 to 255 counts)
WB*n*	Mode 1 Bandwidth Control (0 = Wide, 1 = Narrow)
WC*nnn*	Low correlation threshold (0 to 255 counts)
WD*nnn nnn nnn*	Data Out (Vel;Cor;Amp PG;St;P0 P1;P2;P3)
WE*nnnn*	Error velocity threshold (0 to 5000 mm/s)
WF*nnnn*	Blank after transmit (0 to 9999 cm)
WI*n*	Clip data past bottom (0 = Off, 1 = On)
WJ*n*	Receiver gain select (0 = Low, 1 = High)
WK*n*	Depth Cell Size Override (Mode 11/12 only)
WL*sss,eee*	Water reference layer
WM*n*	Water Profiling mode (1, 5, 8, 11, 12)
W*Nnnn*	Number of depth cells (1 to 128)
WO*x,y*	Mode 12 parameters
WP*nnnn*	Pings per ensemble (0 to 16384)
WQ*n*	Sample ambient sound (0 = Off, 1 = On)
WS*nnnn* [min, max]	Depth cell size (80 to 3200 (75kHz), 40 to 3200 (150kHz), 20 to 800 (300kHz), 10 to 800 (600kHz), 5 to 400 (1200kHz))
WT*nnnn*	Transmit length (0 to 3200 cm)
WU*n*	Ping weight (0 = Box, 1 = Triangle)
WV*nnn*	Ambiguity velocity (002 to 480 cm/s radial)
WZ*nnn*	Mode 5 ambiguity velocity (0 to 999 cm/s)

Table 3: WorkHorse ADCP Factory Defaults

Command	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
BA	N/A	030	030	030	030	030
BB	N/A	0640	0320	160	60	20
BC	N/A	220	220	220	220	220
BD	N/A	000	000	000	000	000
BE	N/A	1000	1000	1000	1000	1000
BF	N/A	00000	00000	00000	00000	00000
BJ	N/A	00000	00000	00000	00000	00000
BI	N/A	040	020	010	005	001
BK	N/A	0	0	0	0	0
BL	N/A	0,50,90	160,320,480	80,160,240	40,60,100	20,20,40
BM	N/A	5	5	5	5	6
BP	N/A	000	000	000	000	000
BR	N/A	0	0	0	0	0
BV	N/A	N/A	N/A	20,250,0	10,250,0	N/A
BX	N/A	5500	02000	1250	450	150
BZ	N/A	004	004	004	004	004
CB	411	411	411	411	411	411
CC	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000
CD	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000	000 000 000
CF	11111	11111	11111	11111	11111	11111
CH	0	0	0	0	0	0
CI	000	000	000	000	000	000
CL	1	1	1	1	1	1
CM	0	0	0	0	0	0
CN	0	0	0	0	0	0
CP	0	0	0	0	0	0
CQ	255	255	255	255	255	255
CX	0	0	0	0	0	0
DB	411	411	411	411	411	411
DW	0	0	0	0	0	0
EA	+00000	+00000	+00000	+00000	+00000	+00000
EB	+00000	+00000	+00000	+00000	+00000	+00000
EC	1500	1500	1500	1500	1500	1500
ED	00000	00000	00000	00000	00000	00000
EH	00000	00000	00000	00000	00000	00000
EP	+0000	+0000	+0000	+0000	+0000	+0000
ER	+0000	+0000	+0000	+0000	+0000	+0000
ES	35	35	35	35	35	35
ET	+2500	+2500	+2500	+2500	+2500	+2500
EX	11111	11111	11111	11111	11111	11111
EZ	1111101	1111101	1111101	1111101	1111101	1111101
HA	255	255	255	255	255	255
HB	05	05	05	05	05	05
HD	111000000	111000000	111000000	111000000	111000000	111000000
HF	22222	22222	22222	22222	22222	22222
HP	0000	0000	0000	0000	0000	0000
HR	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00
HS	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023
HT	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50	00:00:00.50
HV	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023	001,010,021,022,023

Continued Next Page

Table 3: WorkHorse ADCP Factory Defaults (continued)

Command	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
LA	050	050	050	050	050	050
LC	064	065	064	064	064	064
LD	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000
LF	0704	0352	0176	0088	0044	0022
LJ	1	1	1	1	1	1
LN	030	030	030	030	030	030
LP	00000	00000	00000	00000	00000	00000
LS	1600	0800	0400	0200	0100	0050
LV	175	175	175	175	175	175
LW	1	1	1	1	1	1
LZ	030,220	030,220	030,220	030,220	030,220	030,220
PB	01,00,1	01,00,1	01,00,1	01,00,1	01,00,1	01,00,1
PD	00	00	00	00	00	00
PE	00001	00001	00001	00001	00001	00001
PO	1111	1111	1111	1111	1111	1111
SA	001	001	001	001	001	001
SI	00000	00000	00000	00000	00000	00000
SM	0	0	0	0	0	0
SS	0	0	0	0	0	0
ST	00000	00000	00000	00000	00000	00000
SW	00000	00000	00000	00000	00000	00000
TB	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00	00:00:00.00
TC	00000	00000	00000	00000	00000	00000
TE	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00	01:00:00.00
TP	01:20.00	01:20.00	01:20.00	01:20.00	01:20.00	01:20.00
TX	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00
WA	050	050	050	050	050	050
WB	1	1	0	0	0	0
WC	064	064	064	064	064	064
WD	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000	111 100 000
WE	2000	2000	2000	2000	2000	2000
WF	0704	0352	0176	0088	0044	0022
WI	0	0	0	0	0	0
WJ	1	1	1	1	1	1
WK	0	0	0	0	0	0
WL	001,005	001,005	001,005	001,005	001,005	001,005
WM	1	1	1	1	1	Not Available
WN	030	030	030	030	030	030
WO	1,4	1,4	1,4	1,4	1,4	1,4
WP	00045	00045	00045	00045	00045	00045
WQ	0		0	0	0	0
WS	1600 [80,3200]	0800 [40,3200]	0400 [20,1600]	0200 [10,800]	0100[5,400]	0050 [5,200]
WT	0000	0000	0000	0000	0000	0000
WU	0	0	0	0	0	0
WV	175	175	175	175	175	175
WZ	010	010	010	010	010	N/A

NOTE. The highlighted commands have frequency dependent defaults.

2 Command Descriptions

Each listing includes the command's purpose, format, default setting (if applicable) range, recommended setting, and description. When appropriate, we include amplifying notes and examples. If a numeric value follows the command, the WorkHorse ADCP uses it to set a processing value (time, range, percentage, processing flags). All measurement values are in metric units (mm, cm, and dm).

? – Help Menus

Purpose — Lists the major help groups.

Format — *x*? (see description)

Description — Entering ? by itself displays all command groups. To display help for one command group, enter *x*?, where *x* is the command group you wish to view. When the WorkHorse ADCP displays the help for a command group, it also shows the format and present setting of those commands. To see the help or setting for one command, enter the command followed by a question mark. For example, to view the WP-command setting enter WP?.

Examples — See below.

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.xx
Teledyne RD Instruments (c) 1996-2005
All Rights reserved.
>?
Available Menus:
DEPLOY? ------------------ Deployment Commands
SYSTEM? ------------------ System Control, Data Recovery and Testing Commands

Available Commands:

C? ----------------------- CONTROL Commands
E? ----------------------- ENVIRONMENTAL SENSORS Commands
P? ----------------------- PERFORMANCE Commands
S? ----------------------- RDS^3 SYNCHRONIZATION Commands
T? ----------------------- TIMING Commands
W? ----------------------- WATER PROFILING Commands
R? ----------------------- RECORDER Commands
A? ----------------------- SENSOR/COMPASS Commands
O? ----------------------- FEATURE Commands
D? ----------------------- APPLIED MICROSYSTEMS Commands
?? ----------------------- DISPLAY Quick Menus
>
```

Break

Purpose Interrupts WorkHorse ADCP without erasing present settings.

Format <BREAK>

Recommended Setting. Use as needed.

Description A BREAK signal interrupts WorkHorse ADCP processing. It is leading-edge triggered and must last at least 300 ms. A BREAK initializes the system, sends a wake-up (copyright) message, and places the WorkHorse ADCP in the DATA I/O mode. The BREAK command does not erase any settings or data. Using *BBTalk*, pressing the **End** key sends a BREAK.

Example <BREAK>

```
[BREAK Wakeup A]

WorkHorse Broadband ADCP Version 16.xx
Teledyne RD Instruments (c) 1996-2000
All Rights reserved.
>?
```

When you send a break the text inside the brackets '[…]' of the first line of the Wakeup Messages indicates the ADCP's communication configuration:

- **[BREAK Wakeup A]** => ADCP is set to send/receive RS232 communication through the serial lines of the I/O cable
- **[BREAK Wakeup B]** => ADCP is set to send/receive RS432 communication through the serial lines of the I/O cable.
- **[BREAK Wakeup AB]** => RS232/422 switch on the top of the PIO board in the ADCP is in between two positions, but neither RS232 nor RS422. It can also mean that the ADCP received a trigger pulse while in command mode.
- **[ALARM Wakeup A]** => When you send a break, if the battery has a low voltage reading you will get the following message:

```
[ALARM Wakeup A]
WorkHorse Broadband ADCP Version 16.xx
Teledyne RD Instruments (c) 1996-2005
All Rights Reserved.
>
```

CAUTION. If this message appears after a break, it is advised not to deploy the ADCP since TRDI cannot guarantee the unit will perform to the performance specifications.

Software Breaks can be used with *WinRiver*. Start *WinRiver* in the Acquire mode. If you are in the Playback mode, click **File**, **Acquire Mode**. To open the **Communications Settings** dialog box, click **Settings**, **Communications**.

Click the **Properties** button, **General** tab and select the **Use Software Breaks** box. The ADCP will use the "= = =" string instead of a break. Only WorkHorse ADCP firmware 16.21 and above accepts this option.

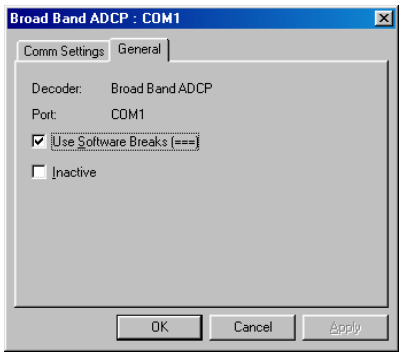


Figure 5. Software Break Setup in *WinRiver*

NOTE. In order for the software breaks to work, the CL command must be set to CL0 (see "CL - Battery Saver Mode," page 41).

Expert Mode

Purpose — Turns on or off the expert mode.

Format — expertoff, experton

Recommended Setting. Use as needed.

Description — When the Expert Off command is used, it limits the amount of commands displayed on the help menu. When the expert mode is turned off, all commands are still available (to ensure software compatibility) but do not display. The Expert On command shows all of the available commands in the help menu.

Examples — See below.

```
expertoff
Expert Mode is Off
>
experton
Expert Mode is On
>
```

OL - Features

Purpose Lists special firmware upgrades that are installed.

Format OL

Recommended Setting. Use as needed.

Description Lists special features that are installed. See "Feature Upgrades," page 5 for information on how to install additional capability in your WorkHorse ADCP.

Examples See below.

```
>ol                              FEATURES
------------------------------------------------------------------------
Feature                                                        Installed
------------------------------------------------------------------------
Bottom Track                                                       Yes
Water Profile                                                      Yes
High Resolution Water Modes                                         No
Lowered ADCP                                                        No
Waves Gauge Acquisition                                             No
See your technical manual or contact TRDI for information on how to
install additional capability in your WorkHorse ADCP.
```

2.1 Compass Commands

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement.

2.1.1 Available Compass Commands

This section lists the available compass commands.

```
>a?
Available Commands:

AC ----------------------- Output Active Fluxgate & Tilt Calibration Data
AD ----------------------- Display Calibration Data
AF ----------------------- Field Calibrate to remove Hard and/or Soft Iron Error
AR ----------------------- Restore Factory Fluxgate Calibration data:
                              make factory the active calibration data
AX ----------------------- Examine Compass Performance
AZ   0.000000 ------------ Zero pressure reading
A? ----------------------- Display Public Sensor Commands

>
```

2.1.2 Compass Command Descriptions

AC – Output Active Calibration Data

Purpose Outputs active fluxgate and tilt calibration data.

Format AC

Recommended Setting. Use as needed.

Description The AC command is identical to the AD command except that the AC command doesn't prompt the user for Factory or Active Calibration data; it assumes active. The AC Command doesn't prompt the user to "press any key to continue..." when the screen is full.

Example See below

```
>ac

              ACTIVE FLUXGATE CALIBRATION MATRICES in NVRAM
               Calibration date and time: 4/6/2000  11:00:29
                              S inverse
          +                                                  +
     Bx   ¦   2.8071e-01 -2.8343e-01 -3.8045e-02  1.1574e-02 ¦
     By   ¦   8.6383e-04  1.8275e-03 -3.8555e-01  2.9522e-03 ¦
     Bz   ¦  -1.3365e-01 -1.2769e-01  4.9614e-03 -2.2870e-01 ¦
     Err  ¦   3.5561e-01  3.3613e-01 -6.3830e-04 -3.9550e-01 ¦
          +                                                  +
                              Coil Offset
                          +                +
                          ¦   3.4253e+04   ¦
                          ¦   3.5362e+04   ¦
                          ¦   3.5650e+04   ¦
                          ¦   3.3749e+04   ¦
                          +                +
                              Electrical Null
                               +       +
```

```
                              ¦ 34575 ¦
                              +       +
                    TILT CALIBRATION MATRICES in NVRAM
                 Calibration date and time: 4/6/2000  10:58:42
               Average Temperature During Calibration was   26.6 °C

                    Up                                Down

        +                           +     +                           +
 Roll   ¦  -3.2219e-07  -1.1456e-05 ¦     ¦   4.2529e-07   1.6306e-05 ¦
 Pitch  ¦  -1.1477e-05   8.4276e-08 ¦     ¦  -1.6188e-05   1.9917e-07 ¦
        +                           +     +                           +

        +                           +     +                           +
 Offset ¦   3.2400e+04   3.2470e+04 ¦     ¦   3.0128e+04   3.2002e+04 ¦
        +                           +     +                           +

                            +       +
                      Null   ¦ 33336 ¦
                            +       +
```

AD – Display Factory or Active Calibration Data

Purpose Displays factory calibration or active calibration data.

Format AD

Recommended Setting. Use as needed.

Description Displays factory calibration or active calibration data.

Example >AD

```
Display factory calibration data or active calibration data [f or a]?a

              ACTIVE FLUXGATE CALIBRATION MATRICES in FLASH
               Calibration date and time: 3/8/1996  09:53:42
                              S inverse
          |                                                   |
     Bx   |   2.9102e-01  2.6325e-01  2.1267e-02  4.0145e-01 |
     By   |   2.7342e-01  2.5335e-01 -4.8691e-02 -3.9508e-01 |
     Bz   |  -1.8192e-01  2.0180e-01  2.3319e-01 -2.7045e-02 |

     Err  |   3.9761e-01 -3.9925e-01  6.4865e-01 -6.0795e-02 |
          |                                                   |
                              Coil Offset
                          |                |
                          |   3.5076e+04   |
                          |   3.3277e+04   |
                          |   3.2996e+04   |
                          |   3.3953e+04   |
                          |                |
                              Electrical Null

                               |       |
                               | 33901 |
                               |       |   press any key to continue...

                    TILT CALIBRATION MATRICES in FLASH
                 Calibration date and time: 12/28/1995  08:13:29
               Average Temperature During Calibration was   23.4° C

                    Up                                Down

        |                           |     |                           |

 Roll   |  -2.1990e-05  -2.8379e-05 |     |   2.6648e-05   3.4953e-05 |
```

```
Pitch  |  -2.9185e-05   2.2630e-05 |      |  -3.5895e-05   2.8521e-05 |
       |                           |      |                           |
       |                           |      |                           |
Offset |   3.1747e+04   3.0144e+04 |      |   3.0434e+04   3.2971e+04 |
       |                           |      |                           |

                              |       |

                     Null     | 33408 |
                              |       |
```

AF – Field Calibrate Compass

Purpose Calibrates the compass to remove hard and soft iron effects.

Format AF

Recommended Setting. Use as needed. The compass must be calibrated if the batteries have been replaced.

TRDI strongly recommends sending the AR command (compass restore) before the AF (field calibrate) command. This is done to prevent corruption of the calibration matrix due to a previous incomplete compass calibration.

Description The built-in automated compass calibration procedures are similar to the alignment verification, but requires three rotations instead of one. The WorkHorse ADCP uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the WorkHorse ADCP for the two calibration rotations, the WorkHorse ADCP checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the ADCP. Hard iron effects are related to residual magnetic fields and cause single cycle errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

NOTE. For details on compass alignment, see the ADCP User's Guide. Single tilt compass calibration has been implemented in firmware version 16.30. For details, see the WinRiver II User's Guide.

AR – Return to Factory Calibration

Purpose Returns to the factory calibration matrix.

Format AR

Recommended Setting. Use as needed. TRDI strongly recommends sending the AR command (compass restore) before the AF (field calibrate) command. This is done to prevent corruption of the calibration matrix due to a previous incomplete compass calibration.

Description If the calibration procedure is not successful (AF-command), return your WorkHorse ADCP to the original factory calibration, by using the AR-command. Try using the AR-command if you have trouble calibrating your compass. In some circumstances, a defective compass calibration matrix can prevent proper calibration.

AX – Examine Compass Calibration

Purpose Used to verify the compass calibration.

Format AX

Recommended Setting. Use as needed.

Description Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the WorkHorse ADCP computes and displays the results. Pay particular attention to the Overall Error.

Example >AX

```
------------------------------------------------------------------------------
                    TRDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.
   Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5°/sec.  Press Q to quit.

 N       NE       E        SE       S       SW       W        NW       N
 ^                ^                ^                ^                 ^
 ********************************************************************************
Accumulating data ...
Calculating compass performance ...

                          >>> Total error:   1.5° <<<

Press D for details or any other key to continue...

HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:

   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5°):  ± 1.55°
```

```
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                ± 1.54°
      Double Cycle Error:                                ± 0.07°
      Largest Double plus Single Cycle Error:            ± 1.61°
      RMS of 3rd Order and Higher + Random Error:        ± 0.31°

      Orientation:    Down
      Average Pitch: -19.29°         Pitch Standard Dev:     0.28°
      Average Roll:   -0.59°         Roll Standard Dev:      0.31°

Successfully evaluated compass performance for the current compass calibra-
tion.
Press any key to continue...
```

AZ – Zero Pressure Sensor

Purpose Zeros the pressure sensor.

Format AZ

Recommended Setting. Use as needed.

Description This command zeros the pressure sensor at the specific location where the ADCP will be used.

NOTE. If the pressure sensor is not installed, using the AZ command will generate the following error.

```
Err: No pressure sensor detected
```

2.2 Bottom Track Commands

NOTE. Bottom Track is a feature upgrade for WorkHorse ADCP Monitor and Sentinel ADCPs (see "Feature Upgrades," page 5). For an instrument to be able to Bottom Track, the feature must be installed (see "OL - Features," page 16).

NOTE. Bottom Track is not available for Long Ranger ADCPs.

Mariner ADCPs use these commands for bottom-tracking applications. Bottom track commands tell the ADCP to collect speed-over-bottom data and detected range-to-bottom data. If the ADCP were facing UP, all bottom-track information would apply to the surface boundary instead of the bottom boundary. The default state of bottom tracking is on (BP0) for WorkHorse ADCPs. Send a BP1 command to turn on the bottom-tracking process.

2.2.1 Available Bottom Track Commands

This section lists the most often used Bottom Track commands.

```
>b?
BA = 030 ----------------- Evaluation Amplitude Min (1-255)
BB = 0060 ---------------- High Bandwidth Maximum Depth (dm)
BC = 220 ----------------- Correlation Magnitude Min (0-255)
BD = 000 ----------------- Delay Re-Acquire (# Ensembles)
BE = 1000 ---------------- Max Error Velocity (mm/s)
BF = 00000 --------------- Depth Guess (0=Auto, 1-65535 = dm)
BI = 005 ----------------- Gain Switch Depth (0-999 meters)
BJ = 00000 --------------- Bottom Blank (1-65535 = cm)
BK = 0 ------------------- Layer Mode (0-Off, 1-On, 2-Lost, 3-No BT)
BL = 040,0060,0100 ------- Layer:  Min Size (dm), Near (dm), Far (dm)
BM = 5 ------------------- Mode (4 wo/PP, 5 w/PP, 6 M1, 7 Lag Hop)
BP = 000 ----------------- Pings per Ensemble
BR = 0 ------------------- Resolution (0 = 4%, 1 = 2%, 2 = 1%)
BS ----------------------- Clear Distance Traveled
BV = 00010,250,0 --------- BM7 Blank(cm), Corr Min(0-255), Short Lag On/Off=1/0
BX = 00450 --------------- Maximum Depth (10-65535 dm)
BZ = 004 ----------------- Coherent Ambiguity Velocity (cm/s radial)
>
```

2.2.2 Bottom Track Command Descriptions

BA - Evaluation Amplitude Minimum

Purpose	Sets the minimum value for valid bottom detection.
Format	BA*nnn*
Range	*nnn* = 1 to 255 counts
Default	BA30

Recommended Setting. The default setting for this command is recommended for most applications.

Description BA sets the minimum amplitude of an internal bottom-track filter that determines bottom detection. Reducing BA increases the bottom-track detection range, but also may increase the possibility of false bottom detections.

BB – High Bandwidth Maximum Depth

Purpose This command lets the user define the depth at which the ADCP switches between 25% and 50% bandwidth.

Format BB*nnnn*

Range *nnnn* = 0 to 9999 dm

Default BB640 (150 kHz), BB320 (300 kHz), BB160 (600 kHz), BB60 (1200 kHz), BB20 (2400 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command lets the user define the depth at which the ADCP switches between 25% and 50% bandwidth. A setting of zero disables 50% bandwidth. A setting of 9999 disables 25% bandwidth.

BC - Correlation Magnitude Minimum

Purpose Sets minimum correlation magnitude for valid velocity data.

Format BC*nnn*

Range *nnn* = 0 to 255 counts

Default BC220

Recommended Setting. The default setting for this command is recommended for most applications.

Description Sets a minimum threshold for good bottom-track data. The ADCP flags as bad any bottom-track data with a correlation magnitude less than this value.

NOTE. A count value of 255 is a perfect correlation (i.e. solid target)

BD - Delay before Reacquire

Purpose	Sets a delay period before trying to reacquire the bottom.
Format	BD*nnn*
Range	*nnn* = 0 to 999 ensembles
Default	BD0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BD sets the number of ADCP ensembles to wait after losing the bottom before trying to track it again. In effect, BD reduces the number of bottom-track pings and increases the water-track ping rate when the bottom becomes out of range. If the ADCP loses track of the bottom, it immediately transmits a series of search pings. If the ADCP can not find the bottom after 16 pings, it will then wait BD ensembles before starting the search sequence again.

Examples If BD = 10, the ADCP waits 10 ADCP ensembles after the automatic search sequence before beginning the search sequence again. If BD = 0 (default), the ADCP continually tries to find the bottom.

BE - Error Velocity Maximum

Purpose	Sets maximum error velocity for good bottom-track data.
Format	BE*nnnn*
Range	*nnnn* = 0 to 9999 mm/s
Default	BE1000

Recommended Setting. The default setting for this command is recommended for most applications.

CAUTION. The default setting is set purposely high and as a result effectively disabled. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description The ADCP uses this parameter to determine good bottom-track velocity data. If the error velocity is greater than this value, the ADCP marks as bad all four beam velocities (or all four coordinate velocities, if transformed). If three beam solutions are allowed (see "EX – Coordinate Transformation," page 51) and only three beams are good, then the data is ac-

cepted since four good beams are needed for error velocity calculation.

BF - Depth Guess

Purpose — Sets a "best-guess" of expected bottom range for internal calculations.

Format — BF*nnnnn*

Range — *nnnnn* = 1 to 65535 dm (0 = automatic)

Default — BF0

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — When set to a non-zero value, the ADCP transmits a fixed pulse based on a given bottom range. This is useful for applications with fixed range bottoms. The command reduces the amount of time the ADCP uses to search for the bottom if lost.

> **CAUTION.** If improperly set, the ADCP may not bottom-track at all if the bottom range varies from the input range.

BI - Gain Switch Depth

Purpose — Selects the maximum vertical distance from the transducer to the bottom at which the ADCP operates at low gain.

Format — BI*nnn*

Range — *nnn* = 0 to 999 meters

Default — BI40 (150 kHz), BI20 (300 kHz), BI10 (600 kHz), BI5 (1200 kHz), BI1 (2400 kHz)

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — When the vertical range to the bottom is less than BI, the unit operates in low gain. When the vertical range is greater than BI, internal logic determines which gain (low or high) is optimal. In high backscatter areas, it may be necessary to raise this setting in order to detect bottom throughout the range of the system.

BJ – Bottom Blank

Purpose Sets the blanking distance for Bottom Tracking.

Format BJ*nnnnn*

Range *nnnnn* = 0 to 65535 cm

Default BJ0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BJ blanks out bad data close to the transducer head, thus creating a window that reduces unwanted data in the ensemble. This allows the WorkHorse ADCP transmit circuits time to recover before beginning the receive cycle.

BK – Water-Mass Layer Mode

Purpose Selects the ping frequency of the water-mass layer ping

Format BK*n*

Range *n* = 0 to 3

Default BK0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BK selects how often the ADCP performs a water-mass layer ping while bottom tracking. The number of water-mass layer pings per ensemble is dependent on the BP-command (bottom pings per ensemble) and this command setting. Use the BL-command to set the location of the water-mass layer.

Table 4: Water-Mass Reference-Layer Modes

Command	Description
BK0	Disables the water-mass layer ping.
BK1	Sends a water-mass layer ping after every bottom-track ping
BK2	Sends a water-mass layer ping after every bottom-track ping that is unable to find the bottom.
BK3	Disables the bottom-track ping and enables the water-mass ping.

BL - Water-Mass Layer Parameters

Purpose Sets bottom-track water-mass layer boundaries and minimum layer size.

Format BL*mmm,nnnn,ffff*

Range — *mmm* = Minimum Layer Size (0 to 999 decimeters) [meters x 10]
nnnn = Near Layer Boundary (0 to 9999 decimeters) [meters x 10]
ffff = Far Layer Boundary (0 to 9999 decimeters) [meters x 10]

Default — BL320,640,960 (150 kHz), BL160,320,480 (300 kHz), BL80,160,240 (600 kHz), BL40,60,100 (1200kHz), BL20,20,40 (2400kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The BL-command sets a water-mass layer. You can use this layer as a reference point when the bottom is out of range or is incorrect. Water-mass layer output data are available when both BK - Water-Mass Layer Mode and BP - Bottom-Track Pings Per Ensemble are nonzero values, and the bottom must be at least the Minimum Layer Size + Near Layer Boundary + 20% of the reported depth away from the transducer. The Far Layer Boundary (ffff) must be less than the maximum profiling distance or the ADCP sends Error Code 011.

The user-defined water-mass layer is used unless the minimum layer comes within 20% of the water boundary (sea floor for down-looking systems; surface for up-looking systems). As the user-defined water-mass layer comes within 20% of the boundary (Figure 6, B), the layer compresses in size until the minimum water-mass layer size is reached. When the boundary moves closer to the transducer (Figure 6, C), no water mass ping will be sent.

NOTE. The water-mass layer is operational only if BP > zero and BK > zero.

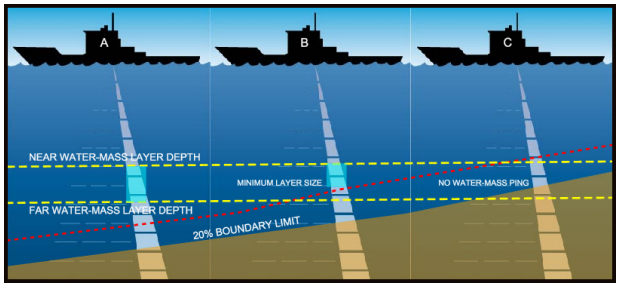


Figure 6. Water-Mass Layer Processing

BM - Bottom Track Mode

Purpose — Sets the Bottom Track mode.

Format — BM*n*

Range — *n* = 4, 5, (see description), 7 (available as a feature upgrade for 1200 kHz WorkHorse ADCP ADCPs with firmware version 16.19 or higher)

Default — BM5 (150, 300, 600, and 1200 kHz), BM6 (2400 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description — See below

Bottom Track Mode 4

Bottom Track Mode 4 uses the correlation side-peak position to resolve velocity ambiguities. It lengthens the lag at a predetermined depth to improve variance.

Bottom Track Mode 5

Bottom Track Mode 5 is similar to Bottom Track Mode 4, but has a lower variance in shallow water by a factor of up to four. In very shallow water at slow speeds, the variance is lower by a factor of up to 100. Bottom Track Mode 5 also has a slightly slower ping rate than Bottom Track Mode 4.

NOTE. Bottom Mode 5 (default setting) will shift to Bottom Mode 4 if the conditions warrant.

The ADCP limits searching for the bottom to the value set by the BX-command (max bottom tracking altitude) + 0.5 transmit length. This allows a faster ping rate when the bottom altitude is close to the BX-command setting.

Table 5: BM4/BM5 Minimum Tracking Depths

Frequency (kHz)	BM4/BM5 Minimum Tracking Depths (m)
150	2.0
300	1.5
600	1.0
1200	0.8

Bottom Track Mode 7

NOTE. Bottom Mode 7 is a feature upgrade for 1200 kHz WorkHorse ADCP ADCPs (see “Feature Upgrades,” page 5). Contact TRDI for information on how to install this capability in your WorkHorse ADCP. Firmware versions prior to version 16.30 allowed Bottom Mode 7 for 600 kHz ADCPs.

Bottom Mode 7 has several advantages over BM5 in slow moving, shallow water applications.

Bottom Mode 7 was developed for even shallower applications than Mode 5 yet it retains bottom Mode 5's very precise velocity measurement (see Table 6). It addresses other shallow water issues such as bottom detection in the presence of high backscatter water, signal level control despite a wide range of bottom backscatter for various applications, and transmit/receive interference when beam depths are substantially different.

Bottom Mode 7 pings at a slower rate than Bottom Mode 5 (1/3 the rate of BM5) and the precision of its velocity measurement degrades at velocities higher than 0.2m/s. If you are interested in using this mode, please request a copy of Field Service Application Note FSA-015 Shallow Water Bottom Tracking Mode 7 (available for download at www.rdinstruments.com, Customer Support page).

Table 6: BM7 Minimum Tracking Depths

Freq	Min Tracking Depths
600kHz	0.6m
1200kHz	0.3m

BP – Bottom-Track Pings per Ensemble

Purpose — Sets the number of bottom-track pings to average together in each data ensemble.

Format — BP*nnn*

Range — *nnn* = 0 to 999 pings

Default — BP0

Recommended Setting. The default setting for this command is recommended for most applications.

Description — BP sets the number of bottom-track pings to average together in each ensemble before sending/recording bottom-track data.

NOTES.

The ADCP interleaves bottom-track pings with water-track pings (see TP- command). If BP = zero, the ADCP does not collect bottom-track data.

The ADCP automatically extends the ensemble interval (TE) if BP x TP > TE.

When using *VmDas* with WorkHorse ADCPs that **do not** support bottom tracking, the BP command will fail on those WorkHorse ADCPs. This is OK if the **ADCP Setup Options** generates the BP command, but a failed command in the command file aborts processing of the command file. The BP command should be removed from the command file in this case. See the *VmDas* User's Guide for details.

BR - Resolution

Purpose	Sets the vertical depth resolution.
Format	BRn
Range	n = 0 to 2 (see description)
Default	BR0

Recommended Setting. The default setting for this command is recommended for most applications.

Description BR sets the vertical depth resolution as a percentage of the overall range detected. The lower the resolution, the finer the depth reading. With BR0 set, if you had a depth of 100 meters, then the depth would read 100 meters until you passed 104 meters. If you had BR2 set, then it would change when you reached 101 meters. Setting a higher resolution (e.g. 1%) results in longer ping times.

BR0 = 4% BR1 = 2% BR2 = 1%

Resolution Setting Limitations:

1) Minimum RSSI Bin Size – The RSSI sampling interval cannot be smaller than the minimum RSSI bin size (for example, 5 cm for a 1200 kHz system). This means that you get the resolution that you command in % or 5 cm (for the above example) - whichever is larger. The minimum RSSI bin sizes vary with system frequency according to the following table:

Frequency	Min RSSI Bin Size
150	37 cm
300	18 cm
600	9 cm
1200	5 cm

2) BM5 Low Altitude Minimum RSSI Bin Size -- This limitation affects only Bottom Mode 5 operation below the following altitudes:

- 150 kHz -- 20 meters -- the resolution becomes 63 cm
- 300 kHz -- 10 meters -- the resolution becomes 16 cm
- 600 kHz -- 5 meters -- the resolution becomes 8 cm
- 1200 kHz -- 2.5 meters -- the resolution becomes 7.8 cm

BS - Clear Distance Traveled

Purpose Clears internal distance traveled accumulators.

Format BS

Recommended Setting. Use as needed.

Description Distance traveled is calculated and output in DVL output formats (PD5 and PD6). The accumulator is zeroed on <BREAK> or by using this command in the manual ensemble cycling mode.

BV – Mode 7 Parameters

Purpose Controls the behavior of Bottom Track Mode 7.

Format BV *aaaaa*, *bbb*, *c*

Range *aaaaa* = 0 to 65535
bbb = 0 to 255
c = 0 or 1 (0 = Off, 1 = On)

Default: BV10, 250, 0 (1200 kHz), BV20,250,0 (600 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description: The first parameter sets the depth at which the bottom will be searched. It avoids locking onto ringing (if any) or very high backscatter water near the transducer.

The second parameter controls the correlation threshold for ambiguity resolving. A lower, fixed correlation threshold is used to determine if a lag's velocity estimate is satisfactory.

The last parameter controls whether short lag velocity estimates are output in the event the longer lag ambiguity cannot be resolved because one or more of the short lag velocity estimates have too low a correlation. If this parameter is a one, then the average of the four short lag estimates that are above

a lower, fixed correlation threshold will be used. If this parameter is a zero, then no velocity will be output for this case.

NOTE. A count value of 255 is perfect correlation.

BX – Maximum Tracking Depth

Purpose	Sets the maximum tracking depth in bottom-track mode.
Format	BX*nnnn*
Range	*nnnn* = 10 to 65535 decimeters (meters x 10)
Default	BX5500 (150 kHz), BX2000 (300 kHz), BX1250 (600 kHz), BX450 (1200 kHz), BX150 (2400 kHz)

Recommended Setting. Set BX to a depth slightly greater than the expected maximum depth.

Description	The BX-command sets the maximum tracking depth used by the ADCP during bottom tracking. This prevents the ADCP from searching too long and too deep for the bottom, allowing a faster ping rate when the ADCP loses track of the bottom. If the bottom-track water reference layer is in use (BK > 0), BX must be greater than the Far Layer Boundary (BLmmm,*nnnn*,ffff), or the ADCP sends Error Code 012.
Example	If you know the maximum depth in the deployment area is 20 meters (200 decimeters), set BX to a value slightly larger than 200 dm, say 210 dm, instead of the default 1250 dm for a 600 kHz ADCP. Now if the ADCP loses track of the bottom, it will stop searching for the bottom at 210-dm (21 m) rather than spend time searching down to 1250-dm (125 m), which is the maximum bottom-tracking range.

BZ - Coherent Ambiguity Velocity

Purpose	Sets the Bottom-Track Mode 5 ambiguity velocity.
Format	BZ*nnn*
Range	*nnn* = 0 to 999 cm/s radial
Default	BZ004

Recommended Setting. The default setting for this command is recommended for most applications.

Description The BZ-command selects the ambiguity velocity used by the bottom-track ping in shallow water when bottom-track Mode 5 is in use.

2.3 Control System Commands

The WorkHorse ADCP uses the following commands to control certain system parameters.

2.3.1 Available Control System Commands

This section lists the available Control System commands.

```
>c?
CB = 411 ----------------- Serial Port Control (Baud [4=9600]; Par; Stop)
CC = 000 000 000 --------- Choose External Devices (x;x;x  x;x;x  x;x;SBMC)
CD = 000 000 000 --------- Serial Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
CE ----------------------- Retrieve Last Ensemble
CF = 11111 --------------- Flow Ctrl (EnsCyc;PngCyc;Binry;Ser;Rec)
CH = 0 ------------------- Suppress Banner
CI = 000 ----------------- Instrument ID (0-255)
CK ----------------------- Keep Parameters as USER Defaults
CL = 1 ------------------- Sleep Enable (0 = Disable, 1 = Enable)
CM = 0 ------------------- RS-232 Sync Master (0 = OFF, 1 = ON)
CN = 1 ------------------- Save NVRAM to recorder (0 = ON, 1 = OFF)
CP = 0 ------------------- PolledMode (1=ON, 0=OFF;  BREAK resets)
CQ = 255 ----------------- Xmt Power (0=Low, 255=High)
CR # --------------------- Retrieve Parameters (0 = USER, 1 = FACTORY)
CS ----------------------- Go (Start Pinging)
CX = 0 ------------------- Trigger Enable (0 = OFF, 1 = ON)
CY # --------------------- Error Status Word (0=Clear, 1=Display)
CZ ----------------------- Power Down Instrument
>
```

2.3.2 Control System Command Descriptions

CB - Serial Port Control

Purpose	Sets the RS-232/422 serial port communications parameters (Baud Rate/Parity/Stop Bits).
Format	CB*nnn*
Range	*nnn* = baud rate, parity, stop bits (see description)
Default	CB411

Recommended Setting. The default setting for this command is recommended for most applications.

Description The WorkHorse ADCP and your external device (dumb terminal, computer software) MUST use the same communication parameters to *talk* to each other. After you enter valid CB parameters, the WorkHorse ADCP responds with a ">" prompt. You may now change the external device's communication parameters to match the WorkHorse ADCP parameters before sending another command.

Table 7: Serial Port Control

Baud Rate	Parity	Stop Bits
0 = 300		
1 = 1200	1 = None (Default)	1 = 1 Bit (Default)
2 = 2400	2 = Even	2 = 2 Bits
3 = 4800	3 = Odd	
4 = 9600 (Default)	4 = Low (Space, logical 0)	
5 = 19200	5 = High (Mark, logical 1)	
6 = 38400		
7 = 57600		
8 = 115200		

Setting The Baud Rate In The WorkHorse ADCP. The WorkHorse ADCP can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the WorkHorse ADCP. This procedure assumes that you will be using the program *BBTalk* that is supplied by Teledyne RD Instruments.

a. Connect the WorkHorse ADCP to the computer and apply power (see the appropriate ADCP User's Guide).

b. Start the *BBTalk* program and establish communications with the ADCP. Wakeup the WorkHorse ADCP by sending a break signal with the **End** key.

c. Send the command CR1 to place the WorkHorse ADCP in the factory default setup.

d. Send the CB-command that selects the baud rate you wish. The following are the typical CB-command settings for different baud rates with no parity and 1 stop bit:

Table 8: Baud Rate

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

e. *BBTalk* will automatically change the settings to match your CB command settings and than *BBTalk* will send the CK command to save the new baud rate setting.

f. Click **File**, **Close** to exit the terminal window.

The WorkHorse ADCP is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB-command.

NOTE. If you send a BREAK before changing the external device's communication parameters, the WorkHorse ADCP returns to the communication parameters stored in non-volatile memory (user settings).

CC - Choose External Devices

Purpose	Selects the external devices used by the ADCP.
Format	CC abc def ghi
Range	Firmware switches (see description)
Default	CC 000 000 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description The CC command uses firmware switches to tell the ADCP the types of data to collect. Setting a bit to one tells the ADCP to collect that data type. The bits are described as follows:

a = Reserved	*d* = Reserved	*g* = Reserved
b = Reserved	e = Reserved	*h* = Reserved
c = Reserved	*f* = Reserved	*i* = Seabird MicroCAT

Example CC 000 000 001 tells the ADCP to collect Seabird MicroCAT data.

NOTE. The data ID for the MicroCAT data is 0800h.

CD – Serial Data Out

Purpose	Selects the serial data types collected by the ADCP.
Format	CD abc def ghi
Range	Firmware switches - Setting a bit to one tells the ADCP to collect that data type. The bits are described as follows.

a = Velocity	*d* = Percent good	*g* = Reserved
b = Correlation	e = Status	*h* = Reserved
c = Echo Intensity	*f* = Reserved	*I* = Reserved

Default CD 000 000 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description The CD command functions like the WD command, except it controls data output serially. If CD is left in the default state (no data selected), the WD setting controls serial and recorded data. If CD is set to anything else, the CD setting controls data output serially, while the WD command controls what is written to the recorder.

CE - Retrieve Most Recent Data Ensemble

Purpose: Output the most recent data ensemble.

Format: CE

Description: CE outputs the most recent data ensemble via the serial communications port in either binary or Hex-ASCII mode as specified by the CF command. The WorkHorse ADCP buffers the last ensemble collected in RAM just prior to it being sent to the recorder or being output to the serial port of the ADCP.

Notes: To retrieve data with the CE command the WorkHorse ADCP must be in command mode, i.e. a break has been sent to stop the automatic ensemble mode, or the prompt has been returned in the manual ensemble mode.

No data is available in the buffer until a deployment has been started (CS command has been sent) and the first ensemble has been completed.

Retrieving the Most Recent Ensemble

The following example assumes that the WorkHorse ADCP has already been deployed and therefore is actively collecting data either on the internal recorder, out the serial port, or both. The following steps will provide the example of how to recover and capture the most recent ensemble.

a. Open the TRDI software program *BBTalk*.

b. Configure the communications for the port that the WorkHorse ADCP is connected to.

c. Click the **B** on the toolbar to send a break to the ADCP.

d. Press the **F3** key to turn on the capture feature in *BBTalk*. Enter a name and path for the file you are about to create.

e. Type the command CE and press enter. The data from the last ensemble will be transferred from the ADCP into the *BBTalk* program and captured to the file you created in Step "d".

f. Press the **F3** key to close the file.

g. Verify the file contains a valid ensemble of data and continue to step "h".

h. Type the command CS and press enter. The ADCP will continue its deployment. Depending on the setting of the RI command, the ADCP will either append to the existing deployment file (starting at ensemble 1) or it will open a new deployment file.

NOTE. If the RI command has been set to disable the auto increment (RI0) of the deployment file then you can at this time decide to close the current data file and start a new file by sending the RDOPEN command. Sending the RDCLOSE command will close the file only and a new file will not be opened until Step "i" is performed and the ADCP collects 8kbytes of data.

CF - Flow Control

Purpose	Sets various WorkHorse ADCP data flow-control parameters.
Format	CF*nnnnn*
Range	Firmware switches (see description)
Default	CF11111

Recommended Setting. The default setting for this command is recommended for most applications.

Description The CF-command defines whether the WorkHorse ADCP: generates data ensembles automatically or manually; generates pings immediately or manually; sends serial output data in binary or Hex-ASCII format; sends or does not send output data to the serial interface; sends or does not send data to the recorder (if installed).

NOTE. The *VmDas* program sets the WorkHorse ADCP to a manual ensemble mode (CF01110) so that it controls when the ensemble occurs.

Table 9: Flow Control

Command	Description
CF1xxxx	Automatic Ensemble Cycling – Automatically starts the next data collection cycle after the current cycle is completed. Only a <BREAK> can stop this cycling.
CF0xxxx	Manual Ensemble Cycling – Enters the STANDBY mode after transmission of the data ensemble, displays the ">" prompt and waits for a new command.
CFx1xxx	Automatic Ping Cycling – Pings immediately when ready.
CFx0xxx	Manual Ping Cycling – Sends a □<□ character to signal ready to ping, and then waits to receive an <Enter> before pinging. The <Enter> sent to the WorkHorse ADCP is not echoed. This feature lets you manually control ping timing within the ensemble.
CFxx2xx	Hex-ASCII Data Output, Carriage Return-Linefeed delimited -- Sends the ensemble in readable hexadecimal-ASCII format with a Carriage Return-Linefeed at the end of each ensemble, if serial output is enabled (see below).
CFxx1xx	Binary Data Output – Sends the ensemble in binary format, if serial output is enabled (see below).
CFxx0xx	Hex-ASCII Data Output – Sends the ensemble in readable hexadecimal-ASCII format, if serial output is enabled (see below).
CFxxx1x	Enable Serial Output – Sends the data ensemble out the RS-232/422 serial interface.
CFxxx0x	Disable Serial Output – No ensemble data are sent out the RS-232/422 interface.
CFxxxx1	Enable Data Recorder – Records data ensembles on the recorder (if installed).
CFxxxx0	Disable Data Recorder – No data ensembles are recorded on the recorder.
Example	CF01010 selects manual ensemble cycling, automatic ping cycling, Hex-ASCII data output, enables serial output, and disables data recording.

CH – Suppress Banner

Purpose — Prevents the unit from sending the wakeup message.

Format — CH*n*

Range — *n* = 0 (display banner), or 1 (suppress banner)

Default — CH0

Recommended Setting. The default setting for this command is recommended for most applications.

Description — If CH1 is saved as part of the User Command Set, the unit will not output a banner on wakeup. The unit will still output the ">" prompt.

CAUTION. Suppression of the wakeup banner may cause some TRDI software to fail or function erratically.

CI – Instrument ID

Purpose Sets the ID for the ADCP.

Format CI*nnn*

Range *nnn* = 0 to 255

Default CI0

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command allows the user to uniquely identify a single ADCP in a network of up to 256 ADCPs. The value to which this command is set will be output in the PD12 output format.

NOTE. This command has no effect if PD is set to other than PD12.

CK - Keep Parameters

Purpose Stores present parameters to non-volatile memory.

Format CK

Recommended Setting. Use as needed.

Description CK saves the present user command parameters to non-volatile memory on the CPU board. The WorkHorse ADCP maintains data stored in the non-volatile memory (user settings) even if power is lost. It does not need a battery. You can recall parameters stored in non-volatile memory with the CR0-command (see "CR – Retrieve Parameters," page 43).

NOTE. Always use the CK command in your configuration file (see "Using Direct Commands to Deploy your ADCP," page 6).

The ADCP automatically stores the last set of commands used in RAM (volatile memory). The user can store the configuration into non-volatile memory by sending a CK command. Note that the ADCP will restart in the previous configuration even if it was not saved with a CK command as long as the volatile memory's internal battery is not discharged. This can happen after several months without any power applied to the ADCP (Note that this battery will recharge as soon as power is reapplied). If the ADCP is stopped by removing the power while pinging, it will restart pinging and output data next time power is applied.

CL - Battery Saver Mode

Purpose — Determines whether the ADCP will attempt to conserve power by sleeping between pings.

NOTE. The CL command is only available for WorkHorse ADCPs with 16.21 or higher firmware.

Format — CLn

Range — n = 0 to 1 (Sleep Between Pings (0 = No, 1 = Yes)

Default — CL1

Recommended Setting. The default setting for this command is recommended for most applications.

Description — CL0 means the ADCP will not make any attempt to conserve power. Setting the CL command to CL1 means the ADCP will attempt to conserve power by going to sleep at every opportunity.

NOTE. In order for software breaks to work, the CL-command must be set to CL0 (see “Break,” page 14).

CM - Master

Purpose — Deprecated. For Lowered ADCP use, see the “Lowered ADCP Commands,” page 105 and the Lowered ADCP User’s Guide.

CN - Save NVRAM to Recorder

Purpose: — Saves the contents of NVRAM to the recorder at the end of a deployment.

Format — CN*n*

Range — n = 0 (On), 1 (Off)

Default — CN1

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The CN command allows the contents of the NVRAM (approx. 8k bytes) to be written to the recorder as part of the deployment record. This can be useful for troubleshooting purposes.

CP – Polled Mode

Purpose: Allows the WorkHorse ADCP to be polled for data.

Format CP*n*

Range *n* = 0 (Off), 1 (On)

Default CP0

Recommended Setting. The default setting for this command is recommended for most applications.

NOTE. The CP command is only available for WorkHorse Sentinel, Monitor, and Long Ranger ADCPs.

Description The CP command allows a WorkHorse ADCP to be polled for data. Setting the CP command to CP1 places the ADCP into a mode where it doesn't sleep. Instead, the ADCP stays awake between pings listening for certain commands (and drawing more power). Polled mode is only recommended for deployments where shore power can be provided. The commands the ADCP responds to while in polled mode are shown in Table 10.

The polled mode requires sufficient time between pings to listen for the polling commands. Setting the TP command to 1 second normally gives the ADCP enough time for polling (see "TP – Time Between Pings," page 81).

CAUTION. In the polled mode (CP1), enough time must be allowed in the ensemble cycle (TE or TP commands) to allow the system to check for serial input. If both TE and TP are set to zero for the maximum ping rate, the system will not recognize any keyboard input with the exception of a <break>.

The output of the polled mode is on demand. If the ADCP is in the middle of an ensemble when the command arrives, it will send out the last completed ensemble, even as it continues to collect data for the current ensemble. Note that the polled mode does not output data until at least one ensemble has been completed.

Table 10: Polled Mode Commands

Command	Description
!	Execute a Break reset
+	Increment internal clock by 1 second
-	Decrement internal clock by 1 second
D	Dump the last ensemble
E	Print the current ensemble number
T	Print the current time

The commands are not echoed and they don't need to be followed by a CR/LF pair. These commands are only available when CP = 1.

CAUTION. Enabling polled mode disables the battery saver feature. Do not enable this mode when running from batteries.

CQ – Transmit Power

Purpose Allows the transmit power to be adjusted.

Format CQ*nnn*

Range *nnn* = 0, or 1 to 255 (0 = Low, 1 to 255 = High)

Default CQ255

Recommended Setting. The default setting for this command is recommended for most applications.

Description Allows the transmit power to be set high or low. This only affects 75 and 150 kHz systems.

CR – Retrieve Parameters

Purpose Resets the WorkHorse ADCP command set to factory settings.

Format CR*n*

Range *n* = 0 (User), 1 (Factory)

Recommended Setting. Use as needed.

Description The WorkHorse ADCP automatically stores the last set of commands used in RAM. The WorkHorse ADCP will continue to be configured from RAM unless it receives a CR- command or until the RAM loses its power.

Table 11: Retrieve Parameters

Format	Description
CR0	Loads into RAM the command set last stored in non-volatile memory (user settings) using the CK-Command.
CR1	Loads into RAM the factory default command set stored in ROM (factory settings).

NOTE. CR keeps the present baud rate and does not change it to the value stored in non-volatile memory or ROM. This ensures the WorkHorse ADCP maintains communications with the terminal/computer.

CS – Start Pinging (Go)

Purpose Starts the data collection cycle (same as the **Tab** key).

Format CS

Recommended Setting. Use as needed. Use *WinSC/VmDas/WinRiver* to create the command file. The CS command will be added to the end of the command file or sent by the software.

Description Use CS (or the **Tab** key) to tell the WorkHorse ADCP to start pinging its transducers and collecting data as programmed by the other commands. If the TF-command is set (time of first ping), the WorkHorse ADCP waits until it reaches the TF time before beginning the data collection cycle.

NOTES.

1. After a CS-command is sent to the WorkHorse ADCP, no changes to the commands can occur until a <BREAK> is sent.
2. If you try to record data (CFxxxx1), and the recorder is full, the WorkHorse ADCP will *not* start pinging and will return a *RECORDER NOT READY* message.

CX – Low Latency Trigger Enable

Purpose Enables or disables the low latency trigger input.

Format CX*n*

Range *n* = 0 (off), 1 (on)

Default CX0

Recommended Setting. The default setting for this command is recommended for most applications. For more information on using the CX command, see FSA-018 (available on www.rdinstruments.com).

Description Turning on the Low Latency Trigger functionality allows the WorkHorse ADCP to ping within ~300µs of the rising edge of the trigger input. The trigger input needs to be on a differential signal pair that starts with a rising edge on one signal line and a falling edge on the other signal line.

CAUTION. The CX command inhibits the ability of the WorkHorse ADCP to sleep and conserve power. Use CX1 only when power consumption is not an issue.

NOTE. If CX1 is used, the CL and SB commands must be set to CL0 and SB0 (see “CL - Battery Saver Mode,” page 41 and (see “SB –Channel B Break Interrupt Mode,” page 113).

CY - Clear Error Status Word

Purpose — Clears the Error Status Word (ESW) stored in EEPROM on the CPU. The ESW is updated whenever an error occurs.

Format — CY*n*

Range — *n* = 0 (Clear), 1 (Display)

Format — Use the CY1 command to display the ESW value or CY0 to clear the ESW.

Recommended Setting. Use as needed.

Description — CY1 displays the active ESW value, which is a 32-bit value displayed in Hex ASCII.

Table 12: Error Status Word

ESW	Description
0x00000001	Bus Error Exception occurred.
0x00000002	Address Error Exception occurred.
0x00000004	Illegal Inst Exception occurred.
0x00000008	Zero Divide Exception occurred.
0x00000010	Emulator Exception occurred.
0x00000020	Unassigned Exception occurred.
0x00000040	Watchdog restart occurred.
0x00000080	Screen Save power down occurred.
0x00000100	Currently pinging.
0x00000200	Unused
0x00000400	Unused
0x00000800	Unused
0x00001000	Unused
0x00002000	Unused
0x00004000	Cold wakeup occurred.
0x00008000	Unknown wakeup occurred.
0x00010000	Clock read failure occurred.
0x00020000	Unexpected Alarm.
0x00040000	Clock jump forward.
0x00080000	Clock jump backward.
0x00100000	Unused
0x00200000	Unused
0x00400000	Unused
0x00800000	Unused
0x01000000	Unused
0x02000000	Unused
0x04000000	Unused
0x08000000	Power Fail (Unrecorded)
0x10000000	Spurious level 4 interrupt (DSP).
0x20000000	Spurious level 5 interrupt (UART).
0x40000000	Spurious level 6 interrupt (CLOCK).
0x80000000	Level 7 interrupt occurred.

In the command mode, the Error Status Word (ESW) codes can be cleared through the CY-command. In ping mode, the ESW is cleared (set to zero) between each ensemble. The values are logically OR'ed. For example, if an illegal instruction (xxx4) and a divide by zero error (xxx8) occurred since the last time the ESW was cleared, a value of "xxxC" would appear as the ESW.

NOTE. ESW code 0x0000100 can only be seen if the CY-command is issued between CS-commands in the manual ping mode. This flag is used to determine if on wakeup, whether the ADCP was pinging or not previous to the present power up. A CS-command sets this bit; a <BREAK> resets the bit. This results in the following consequences:

a) A deployment must be ended with a <BREAK>. If the ADCP is pinging, and power is lost, when power is restored, the ADCP will continue to ping.

b) If the ADCP is in the command mode when power is lost, when power is restored, it will wakeup in the command mode. If a timeout occurs, the ADCP will power down automatically.

NOTE. In ping mode, the ESW is cleared (set to zero) between each ensemble. The ESW is written to the ensemble (see "Variable Leader Data Format," page 132).

CZ – Power Down WorkHorse ADCP

Purpose Tells the WorkHorse ADCP to power down.

Format CZ

Recommended Setting. Use as needed.

Description Sending the CZ-command powers down the WorkHorse ADCP. WorkHorse ADCP processing is interrupted and the WorkHorse ADCP goes in the STANDBY mode (RAM is maintained).

Example See below

```
>cz

Powering Down
```

NOTES.

1. When powered down using the CZ-command, the WorkHorse ADCP still draws up to 30μa, but wakes up periodically (every 8 to 12 hours) for a few seconds to maintain RAM.

2. This command should be used whenever batteries have been installed and you do not send commands to start a deployment. If you do not use the CZ-command, the WorkHorse ADCP will draw up to 50 milli-amps of current. *A new battery will be discharged in a few days*.

3. Performance and testing commands (i.e. AF, PA, PT, RB, and RY) override the battery saver functions. For example, using the RY-command to recover data from the ADCP while on battery power will disable the automatic power saver mode. If a CZ-command is not used after all data has been recovered, the ADCP will remain in the command mode. TRDI recommends disconnecting the batteries and using the AC power adapter while testing or recovering data.

2.4 Environmental Commands

The WorkHorse ADCP uses the following commands to control the environmental and positional information that affects internal data processing.

2.4.1 Available Environmental Commands

This section lists the available Environmental commands.

```
>e?
EA = +00000 -------------- Heading Alignment (1/100 deg)
EB = +00000 -------------- Heading Bias (1/100 deg)
EC = 1500 ---------------- Speed Of Sound (m/s)
ED = 00000 --------------- Transducer Depth (0 - 65535 dm)
EH = 00000 --------------- Heading (1/100 deg)
EP = +0000 --------------- Tilt 1 Sensor (1/100 deg)
ER = +0000 --------------- Tilt 2 Sensor (1/100 deg)
ES = 35 ------------------ Salinity (0-40 pp thousand)
ET = +2500 --------------- Temperature (1/100 deg Celsius)
EX = 11111 --------------- Coord Transform (Xform:Type; Tilts; 3Bm; Map)
EZ = 1111101 ------------- Sensor Source (C;D;H;P;R;S;T)
>
```

2.4.2 Environmental Command Descriptions

EA - Heading Alignment

Purpose — Corrects for physical misalignment between Beam 3 and the heading reference.

Format — EA±*nnnnn*

Range — ±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)

Default — EA00000

Recommended Setting. For systems that are stationary, EA is typically set to zero (default), since Beam 3 is used as the heading reference. This command is added to the command file using *WinSC*.

Description — EA is a heading alignment angle (referenced to Beam 3) used as a new zero reference for heading output and for transformation to earth coordinates. Use the EB-command to correct for heading bias (e.g., magnetic declination).

Example — The ADCP is mounted in place on a moving ship. Beam 3 has been rotated 45 clockwise (+45) from the ship's centerline. Use the EA command to tell the ADCP where beam 3 is in relation to the ship's centerline. To convert +45 to an EA-command value, multiply the desired alignment angle in degrees by 100:

```
EA = +45.00 × 100 = +4500 = EA+04500
```

EB - Heading Bias

Purpose — Corrects for electrical/magnetic bias between the ADCP heading value and the heading reference.

Format — EB±*nnnnn*

Range — ±*nnnnn* = -17999 to 18000 (-179.99 to 180.00 degrees)

Default — EB00000

Recommended Setting. Use EB to counteract the effects of magnetic declination at the deployment site. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description — EB is the heading angle that counteracts the electrical bias or magnetic declination between the ADCP and the heading source. Use the EA-command to correct for physical heading misalignment between the ADCP and a vessel's centerline.

Examples — A bottom-mounted ADCP is receiving heading from its internal compass. A navigation map for the deployment area shows a declination of 10°10′W 1995 (9′E/year). This means the magnetic offset in the year 2001 at this location is (- (10+10/60) + (9/60*6)) = -9.26666 degrees. Set the EB command value to EB-926.

EC - Speed of Sound

Purpose — Sets the speed of sound value used for ADCP data processing.

Format — EC*nnnn*

Range — *nnnn* = 1400 to 1600 meters per second

Default — EC1500

Recommended Setting. The default setting for this command is recommended for most applications.

Description — EC sets the sound speed value used by the ADCP to scale velocity data, depth cell size, and range to the bottom. The ADCP assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.

NOTE. If the EZ Speed of Sound field = 1, the ADCP overrides the manually-set EC value and calculates speed of sound using the values determined by transducer depth (ED), salinity (ES), and transducer temperature (ET). EZ also selects the source for ED, ES, and ET.

ED - Depth of Transducer

Purpose — Sets the ADCP transducer depth.

Format — ED*nnnnn*

Range — *nnnnn* = 0 to 65535 decimeters (meters x 10)

Default — ED00000

> **Recommended Setting.** Use the EZ-command (set by *WinSC*).

Description — ED sets the ADCP transducer depth. This measurement is taken from sea level to the transducer faces. The ADCP uses ED in its speed of sound calculations. The ADCP assumes the speed of sound reading is taken at the transducer head. See the primer for information on speed of sound calculations.

Note — If the EZ *Transducer Depth* field = 1, the ADCP overrides the manually set ED value and uses depth from the internal pressure sensor. If a pressure sensor is not available, the ADCP uses the manual ED setting.

EH - Heading

Purpose — Sets the ADCP heading angle.

Format — EH*nnnnn*

Range — *nnnnn* = 0 to 35999 (000.00 to 359.99 degrees)

> **Recommended Setting.** Use the EZ-command.

Description — EH sets the ADCP heading angle of beam 3. When mounted on a stationary platform, the ADCP assumes beam 3 points north (0).

Example — Convert heading values of 34 and 3.5 to EH-command values.

```
EH = 34.00 × 100 = 3400 = EH03400
EH =  3.50 × 100 =  350 = EH00350
```

> **NOTE.** If the EZ Heading field = one, the ADCP overrides the manually set EH value and uses heading from the transducer's internal sensor. If the sensor is not available, the ADCP uses the manual EH setting.

EP - Pitch (Tilt 1)

Purpose — Sets the ADCP pitch (tilt 1) angle.

Format — EP±*nnnn*

Range — ±*nnnn* = -6000 to 6000 (-60.00 to +60.00 degrees)

Recommended Setting. Use the EZ-command.

Description EP sets the ADCP pitch (tilt 1) angle.

Example Convert pitch values of +14 and -3.5 to EP-command values.

```
EP = 14.00 × 100 = 1400 = EP01400 (+ is understood)
EP = -3.50 × 100 = -350 = EP-00350
```

NOTE. If the EZ Pitch field = 1, the ADCP overrides the manually set EP value and uses pitch from the transducer's internal tilt sensor. If the sensor is not available, the ADCP uses the manual EP setting.

ER - Roll (Tilt 2)

Purpose Sets the ADCP roll (tilt 2) angle.

Format ER±*nnnn*

Range ±*nnnn* = -6000 to 6000 (-60.00 to +60.00 degrees)

Recommended Setting. Use the EZ-command.

Description ER sets the ADCP roll (tilt 2) angle.

Example Convert roll values of +14 and -3.5 to ER-command values.

```
ER = 14.00 × 100 = 1400 = ER01400 (+ is understood)
ER = -3.50 × 100 = -350 = ER-00350
```

NOTE. If the EZ Roll field = one, the ADCP overrides the manually set ER value and uses roll from the transducer's internal tilt sensor. If the sensor is not available, the ADCP uses the manual ER setting.

ES – Salinity

Purpose Sets the water's salinity value.

Format ES*nn*

Range *nn* = 0 to 40

Default ES35

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*. The default setting for this command is recommended for most applications.

Description ES sets the water's salinity value. The WorkHorse ADCP uses ES in its speed of sound calculations. The WorkHorse ADCP assumes the speed of sound reading is taken at the transducer head.

ET - Temperature

Purpose — Sets the water's temperature value.

Format — ET±*nnnn*

Range — ±*nnnn* = -500 to 4000 (-5.00 C to +40.00 C)

Default — ET2500

Recommended Setting. Use the EZ-command.

Description — ET sets the temperature value of the water. The ADCP uses ET in its speed of sound calculations (see the primer). The ADCP assumes the speed of sound reading is taken at the transducer head.

Example — Convert temperatures of +14 C and -3.5 C to ET-command values.

```
ET = 14.00 × 100 = 1400 = ET1400 (+ is understood)
ET = -3.50 × 100 = -350 = ET-0350
```

NOTE. If the EZ Temperature field = one, the ADCP overrides the manually set ET value and uses temperature from the transducer's temperature sensor. If the sensor is not available, the ADCP uses the manual ET setting.

EX – Coordinate Transformation

Purpose — Sets the coordinate transformation processing flags.

Format — EX*xxptb*

Range — *xx* = Transformation
p = Pitch and Roll
t = 3 beam solutions
b = Bin mapping

Default — EX11111

Recommended Setting. The default setting for this command is recommended for most applications.

Description — EX sets firmware switches that control the coordinate transformation processing for velocity and percent-good data.

NOTE. *VmDas* sets the WorkHorse ADCP to Beam Coordinates (EX00001).

Table 13: Coordinate Transformation Processing Flags

Setting	Description
EX00xxx	No transformation. Radial beam coordinates, I.E., 1, 2, 3, 4. Heading/Pitch/Roll not applied.
EX01xxx	Instrument coordinates. X, Y, Z vectors relative to the ADCP. Heading/Pitch/Roll not applied.
EX10xxx	Ship coordinates (Note 1) X, Y, Z vectors relative to the ship. Heading not applied. EA-command used, but not the EB-command. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EX11xxx	Earth coordinates (Note 1) East, North, Vertical vectors relative to Earth. Heading applied. EA and EB-commands used. If Bit 3 of the EX-command is a 1, then Pitch/Roll applied.
EXxx1xx	Use tilts (pitch and roll) in transformation (see Note 2)
EXxxx1x	Allows 3-beam solutions if one beam is below the correlation threshold set by WC
EXxxxx1	Allow bin mapping (see Note 4 and 5)

NOTES.

1. For ship and earth-coordinate transformations to work properly, you must set the Heading Alignment (EA) and Heading Bias (EB) correctly. You also must ensure that the tilt and heading sensors are active (EZ).

2. Setting EX bit 3 (Use Tilts) to 0 lets you collect tilt data without using it in the ship or earth-coordinate transformations.

3. Each WorkHorse ADCP uses its own beam calibration matrix to correct data for beam pointing errors (e.g., if the beams erroneously point toward 21 degrees instead of 20 degrees). Correction is applied when the data are converted from beam coordinates to earth coordinates. If you output beam-coordinate data, you will need to apply the beam corrections yourself if you want the best possible data or use the *VmDas* software.

4. TRDI outputs the Bin 1 position for a level system only. We do not adjust the bin 1 position, or the cell sizes, for any tilt. Bin mapping attempts to combine data from sections of the beams that are at the same depth in the water, and does not make any attempt to calculate how that depth might change for a tilted system. The setting of the EX command has no effect on the reported bin 1 distance or the cell size.

5. Bin mapping has been implemented for Ship Coordinate Transforms in firmware version 16.30 or higher.

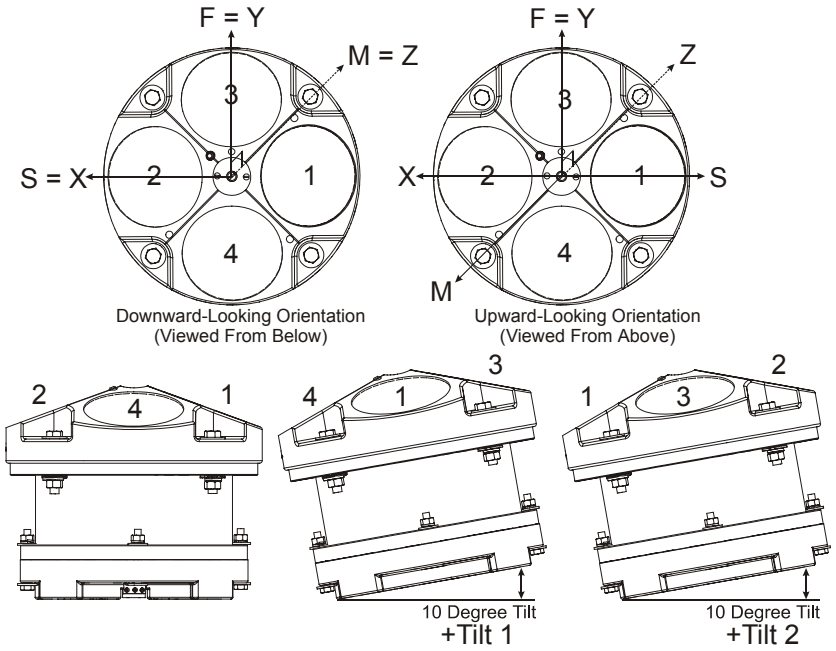


Figure 7. ADCP Coordinate Transformation

Sign of Angle for a Unit Facing	Up	Down
Tilt 1 (Pitch) Beam 3 higher than Beam 4	+	+
Tilt 2 (Roll) Beam 2 higher than Beam 1	+	-

EZ - Sensor Source

Purpose Selects the source of environmental sensor data.

Format EZ*cdhprst*

Default EZ1111101

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Range Firmware switches (see description)

Description Setting the EZ-command firmware switches tells the ADCP to use data from a manual setting or from an associated sensor. When a switch value is non-zero, the ADCP overrides the manual E-command setting and uses data from the appropriate sensor. If no sensor is available, the ADCP defaults to the manual E-command setting. The following table shows how to interpret the sensor source switch settings.

Table 14: Sensor Source Switch Settings

	Field	Value = 0	Value = 1	Value = 2	Value = 3
c	Speed Of Sound	Manual EC	Calculate using ED, ES, and ET	N/A	N/A
d	Depth	Manual ED	Depth Sensor	N/A	N/A
h	Heading	Manual EH	Internal Transducer Sensor	N/A	Use NMEA HDT
p	Pitch (Tilt 1)	Manual EP	Internal Transducer Sensor	N/A	N/A
r	Roll (Tilt 2)	Manual ER	Internal Transducer Sensor	N/A	N/A
s	Salinity	Manual ES	N/A	N/A	N/A
t	Temperature	Manual ET	Internal Transducer Sensor	N/A	N/A

Example EZ1111101 means calculate speed of sound from readings, use pressure sensor, transducer heading, internal tilt sensors, and transducer temperature.

Setting the third parameter of the EZ command to 3 (EZxx3xxxx) allows the NMEA heading to be used rather than the ADCP's internal heading sensor. Please refer to FSA-017 – Using NMEA Heading strings with a Navigator for further details. This is available for WorkHorse ADCPs with firmware version 16.26 or higher.

2.5 Fault Log Commands

The WorkHorse ADCP uses the following commands to aid in troubleshooting and testing.

2.5.1 Available Fault Log Commands

This section lists the most often used Fault Log commands.

```
>f?
Available Commands:

FC ----------------------- Clear Fault Log
FD ----------------------- Display Fault Log
FX ----------------------- Toggle the Fault Log debug flag
F? ----------------------- Display Fault Log Commands

>
```

2.5.2 Fault Log Command Descriptions

FC – Clear Fault Log

Purpose Clears the fault log.

Format FC

Recommended Setting. Use as needed.

Description Use this command to clear the fault log of all previous entries.

FD – Display Fault Log

Purpose Displays the fault log.

Format FD

Recommended Setting. Use as needed.

Description Displaying the fault log will list why a built-in test failed. This may aid in troubleshooting.

Example >FD

```
Total Unique Faults   =     2
Overflow Count        =     0
Time of first fault:    97/11/05,11:01:57.70
Time of last fault:     97/11/05,11:01:57.70

Fault Log:
Entry #  0 Code=0a08h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt axis X over range.
Entry #  1 Code=0a16h  Count=    1  Delta=    0 Time=97/11/05,11:01:57.70
 Parameter = 00000000h
  Tilt Y axis ADC under range.
End of fault log.
```

2.6 Performance and Testing Commands

The WorkHorse ADCP uses the following commands for calibration and testing.

2.6.1 Available Performance and Testing Commands

This section lists the available Performance and Testing commands.

```
>p?
PA ----------------------- Pre-Deployment Tests
PB = 01,00,1 ------------- PD12 Bin Select (first;num;sub)
PC ### ------------------- Built In Tests, PC 0 = Help
PD = 00 ------------------ Data Stream Select (0-18)
PE = 00001 --------------- PD12 Ensemble Select (1-65535)
PM ----------------------- Distance Measure Facility
PO = 1111 ---------------- PD12 Velocity Component Select (v1;v2;v3;v4)
PS # --------------------- Show Sys Parms (0=Xdcr,1=FLdr,2=VLdr,3=Mat,4=Seq)
PT ### ------------------- Built In Tests, PT 0 = Help
>
```

2.6.2 Performance and Testing Command Descriptions

PA – Pre-deployment Tests

Purpose — Sends/displays results of a series of WorkHorse ADCP system diagnostic tests.

Format — PA

Recommended Setting. Use as needed.

Description — These diagnostic tests check the major WorkHorse ADCP modules and signal paths. We recommend you run this command before a deployment. These tests check the following boards/paths.

- CPU - CPU RAM and real-time clock.
- Recorder - verifies recorder operation.
- DSP - RAM, registers, and DSP-to-CPU Communications.
- System Tests - A test signal is routed through the DSP and back to the CPU. This checks the main electronics processor path.
- Receive Path - quiescent RSSI levels are checked for [20 < RSSI < 60 counts] and the RSSI filters are checked for proper time constants.
- Transmit Path - checks transmit voltage, current, and impedance.
- Sensors - verifies sensor operation.

Example — see below

```
>PA
PRE-DEPLOYMENT TESTS
CPU TESTS:
  RTC.....................................PASS
  RAM.....................................PASS
  ROM.....................................PASS
RECORDER TESTS:
  PC Card #0..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
  PC Card #1..............................DETECTED
    Card Detect...........................PASS
    Communication.........................PASS
    DOS Structure.........................PASS
    Sector Test (short)...................PASS
DSP TESTS:
  Timing RAM..............................PASS
  Demod  RAM..............................PASS
  Demod  REG..............................PASS
  FIFOs...................................PASS
SYSTEM TESTS:
  XILINX Interrupts... IRQ3  IRQ3  IRQ3 ...PASS
  Receive Loop-Back.......................PASS
  Wide Bandwidth..........................PASS
  Narrow Bandwidth........................PASS
  RSSI Filter.............................PASS
  Transmit................................PASS
SENSOR TESTS:
  H/W Operation...........................PASS
```

NOTE. Wide Bandwidth and Narrow Bandwidth may fail if transducer is not in water. H/W Operation test will fail if the transducer is on its side.

PB - Bin Select for PD12, PD16, and PD18 Data Output Type

Purpose	Selects which bins are output in the PD12, PD16, and PD18 data formats.
Format	PB*x,y,z*
Range	*x* 1 to 128 *y* 0 to 128 *z* 1 to 7
Default	PB1,0,1

Recommended Setting. The default setting for this command is recommended for most applications.

Description The PB command selects which bins are to be output by the ADCP. The *x* parameter indicates the first bin selected for output. The *y* parameter selects the number of bins to be output. A value of zero for *y* indicates that all remaining bins should be output. Beginning with bin *x*, every *z*th bin will be output until *y* total bins have been output.

NOTES.

1. This command has no effect if PD is set to other than PD12, PD16, or PD18.
2. You cannot output bins that have not been collected by setting the WN command.

PC – User-Interactive Built-In Tests

Purpose	Sends/displays results of user-interactive WorkHorse ADCP system diagnostic tests.
Format	PC*nnn*
Range	*nnn* = 0 to 2 (PC0 = Help menu; see below for others)

Recommended Setting. Use as needed.

Description	These diagnostic tests check beam continuity and sensor data. Both tests require user interaction (see examples).
Examples	See below.

PC0 – Help Menu

Sending PC0 displays the help menu.

```
User Interactive, Built In Tests
--------------------------------
PC0 = Help
PC1 = Beam Continuity
PC2 = Sensor Data
```

PC1 – Beam Continuity

Sending PC1 tests the beam continuity by measuring the quiescent Receiver Signal Strength Indicator (RSSI) levels. There must be a change of more than 30 counts when the transducer face is rubbed.

```
BEAM CONTINUITY TEST
When prompted to do so, vigorously rub the selected
beam's face.
If a beam does not PASS the test, send any character to
the ADCP to automatically select the next beam.

Collecting Statistical Data...
  52  48  50  43
Rub Beam 1 = PASS
Rub Beam 2 = PASS
Rub Beam 3 = PASS
Rub Beam 4 = PASS
```

PC2 – Display Heading, Pitch, Roll, and Orientation

Sending PC2 displays heading, pitch angle, roll angle, up/down orientation and attitude temperature in a repeating loop at approximately 0.5-sec update rate. Press any key to exit this command and return to the command prompt.

```
Press any key to quit sensor display ...
Heading   Pitch    Roll   Up/Down    Attitude Temp   Ambient Temp  Pressure
301.01°  -7.42°  -0.73°     Up          24.35°C         22.97°C        0.0 kPa
300.87°  -7.60°  -0.95°     Up          24.36°C         22.97°C        0.0 kPa
300.95°  -7.60°  -0.99°     Up          24.37°C         22.97°C        0.0 kPa
300.71°  -7.61°  -0.96°     Up          24.37°C         22.98°C        0.0 kPa
300.69°  -7.61°  -0.96°     Up          24.35°C         22.98°C        0.0 kPa
300.76°  -7.60°  -0.98°     Up          24.38°C         22.97°C        0.0 kPa
```

NOTE. The PC2 heading shows the raw (magnetic north) heading only. The EB command (Heading Bias) is **not** applied.

PD - Data Stream Select

Purpose: Selects the type of ensemble output data structure.

Format: PDn

Range n = 0 to 18 (see description)

Default PD0

Recommended Setting. The default setting for this command is recommended for most applications.

Description: PD selects the normal output data structure, a special application data structure, or a fixed data set for transmission/display as the data ensemble (see Table 15).

Table 15: Data Stream Selections

Format	Description
PD0	Sends The real water-current data set
PD1	Sends an TRDI-defined data set that always uses the same data (except for parts of the leader data). This data set is useful during user-software development.
PD2	Not used.
PD3	Sends Paramax-DVL ensemble output data structure.
PD4	Sends CSS-DVL output data structure (without sensor and made-good data).
PD5	Sends CSS-DVL output data structure (with sensor and made-good data).
PD6	Sends a special DVL ASCII data stream
PD7	Not used
PD8	Sends ensemble data as formatted ASCII text. A new-line character terminates each line. Two new-line characters terminate an ensemble.
PD9	Sends ensemble data as formatted comma delimitated ASCII text.

Format	Description
PD10	Send a special DVL output data format.
PD12	Send the reduced data output format.
PD14	Send the H-ADCP Condensed 2D Output Format
PD15	The PD15 Output Data Format is designed for NDBC satellite data links.
PD16	Sea-Bird acoustic modem
PD18	PD18 is the same Output Data Format as PD16, but with the leading '$' necessary to fully comply with the NMEA format.

NOTE. All of TRDI's software supports PD0 formatted data only.

PE - PD12 Ensemble Select

Purpose Selects which ensembles are output in the PD12 data format.

Format PE*nnnnn*

Range *nnnnn* = 0 to 65535

Recommended Setting. Use as needed.

Description The PE command selects which ensembles are to be output by the ADCP when PD12 is selected. Ensemble numbers 1,1+*n*,1+2*n*,… will be output.

NOTE. This command has no effect if PD is set to other than PD12.

PM - Distance Measurement Facility

Purpose Lets you measure distance over the bottom.

Format PM

Recommended Setting. For TRDI use only.

Description PM lets you use the ADCP to measure distances over the bottom using a dumb terminal.

PO - PD12 Velocity Component Select

Purpose: Selects the velocity components to be output in the PD12 data format.

Format: PO*abcd*

Range: 0 to 1 for *a-d*

Default PO1111

Recommended Setting. The default setting for this command is recommended for most applications.

Description: The PO command selects the velocity components that are output in the PD12 data format. The meaning of the four bits of this command also depends on the first two bits of the EX command as shown below.

EX00xxx - Beam Coordinates

a = beam 4 *b* = beam 3 *c* = beam 2 *d* = beam 1

EX01xxx - Instrument Coordinates

a = Error Velocity *b* = Z axis *c* = Y axis *d* = X axis

EX10xxx - Ship Coordinates

a = Error Velocity *b* = Mast *c* = Forward *d* = Starboard

EX11xxx - Earth Coordinates

a = Error Velocity *b* = Up *c* = North *d* = East

NOTE. This command has no effect if PD is set to other than PD12.

PS – Display System Parameters

Purpose Sends/displays WorkHorse ADCP system configuration data.

Format PS*n*

Range *n* = 0, 3 (see description)

Recommended Setting. Use as needed.

Description See below.

PS0 – System Configuration

PS0 sends the WorkHorse ADCP hardware/firmware information. For example, the output may look like this:

```
>ps0
  Instrument S/N:  0
       Frequency:  307200 HZ
   Configuration:  4 BEAM, JANUS
     Match Layer:  10
      Beam Angle:  20 DEGREES
    Beam Pattern:  CONVEX
     Orientation:  DOWN
       Sensor(s):  HEADING  TILT 1  TILT 2  DEPTH  TEMPERATURE  PRESSURE
Pressure Sens Coefficients:
              c3 = +0.000000E+00
              c2 = +0.000000E+00
              c1 = -2.500000E-03
          Offset = +0.000000E+00

Temp Sens Offset:  -0.20 degrees C

    CPU Firmware:  16.xx
   Boot Code Ver:  Required:  1.13   Actual:  1.13
    DEMOD #1 Ver:  ad48, Type:  1f
    DEMOD #2 Ver:  ad48, Type:  1f
    PWRTIMG  Ver:  85d3, Type:   6
Board Serial Number Data:
   08  00 00 02 C9 20 A7  09 CPU727-2000-00H
   4D  00 00 00 D4 97 37  09 PIO727-3000-03C
>
```

PS3 – Instrument Transformation Matrix

PS3 sends information about the transducer beams. The WorkHorse ADCP uses this information in its coordinate-transformation calculations; for example, the output may look like this:

```
ps3
Beam Width:   3.7 degrees

Beam     Elevation     Azimuth
  1         -70.14      269.72
  2         -70.10       89.72
  3         -69.99        0.28
  4         -70.01      180.28

Beam Directional Matrix (Down):
  0.3399    0.0017    0.9405    0.2414
 -0.3405   -0.0017    0.9403    0.2410
 -0.0017   -0.3424    0.9396   -0.2411
  0.0017    0.3420    0.9398   -0.2415

Instrument Transformation Matrix (Down):    Q14:
  1.4691   -1.4705    0.0078   -0.0067       24069  -24092     127    -109
 -0.0068    0.0078   -1.4618    1.4606        -111     127  -23950   23930
  0.2663    0.2657    0.2657    0.2661        4363    4354    4353    4359
  1.0367    1.0350   -1.0359   -1.0374       16985   16957  -16972  -16996
Beam Angle Corrections Are Loaded.
>
```

If the WorkHorse ADCP needs beam angle corrections, a TRDI calibrated beam angle matrix is loaded into the instrument. This is done when the instrument is manufactured. For more details, request a copy of the ADCP Coordinate Transformation booklet (available for download at www.rdinstruments.com).

PT - Built-In Tests

Purpose Sends/displays results of ADCP system diagnostic test.

Format PT*nnn*

Range *nnn* = 0 to 200 (PT0 = Help menu)

Recommended Setting. Use as needed.

Description These diagnostic tests check the major ADCP modules and signal paths. Most of the tests give their final results in the format;

```
xxxxxxxxxx TEST RESULTS = $hhhh ... rrrr
```

Where

xxxxxxxxxx = Module or path being tested

$hhhh = Hexadecimal result code ($0 = PASS; see individual tests for description of bit results)

rrrr = Overall test result ("PASS" or "FAIL")

PT Test Results Error Codes

To find what bits are set when an error occurs, use the following tables.

Table 16: Error Code Hex to Binary Conversion

Hex Digit	Binary	Hex Digit	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

To convert error code $32CF (note: the dollar sign "$" signifies hexi-decimal), convert 32CF to binary. Error code $32CF has the following bits set: 13, 12, 9, 7, 6, 3, 2, 1, 0.

Hex Digit $	3				2				C				F			
Binary	0	0	**1**	**1**	0	0	**1**	0	**1**	**1**	0	0	**1**	**1**	**1**	**1**
Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

PT0 - Help

Displays the test menu (shown below). As implied by the NOTE, adding 100 to the test number repeats the test continually until the ADCP receives a <BREAK>. Sending PT200 runs all tests. PT300 runs all tests continually until the ADCP receives a <BREAK>.

```
>PT0
Built In Tests
---------------
PT0 = Help
PT1 = NA
PT2 = Ancillary System Data
PT3 = Receive Path
PT4 = Transmit Path
PT5 = Electronics Wrap Around
PT6 = Receive Bandwidth
PT7 = RSSI Bandwidth
NOTE: Add 100 for automatic test repeat
PT200 = All tests
```

PT2 - Ancillary System Data

This test displays the values for ambient and attitude temperature and the contamination sensor (TRDI use only). The ambient temperature is measured on the receiver board. This sensor is imbedded in the transducer head, and is used for water temperature reading. The attitude temperature is measured on the PIO board under the compass. If one of the sensors fails, the PC2 test will show both sensors at the same value. The ADCP will use the attitude temperature if the ambient temperature sensor fails. A reading ≥+55° may indicate a shorted sensor, and a reading ≥-32° may indicate an open sensor.

```
>PT2
  Ambient  Temperature =    21.10 Degrees C
  Attitude Temperature =    21.39 Degrees C
  Internal Moisture    = 8D50h
```

PT3 - Receive Path

This test displays receive path characteristics. The test result is given as eight nibbles (1 nibble = 4 bits). Each nibble represents the result for a particular beam (most significant nibble = beam 1, least significant nibble = beam 8) (four beam ADCPs utilize the four most significant nibbles). In this example, we only describe which bit is set for beam 2 for a given failure type. This test has three parts.

- Part 1 - The ADCP pings without transmitting and displays the result of an autocorrelation function performed over 14 lag periods (only the first 8 are displayed). Ideally, we should see high correlation at near-zero lags, and then see decorrelation as the lags get longer. High correlation values at longer lags indicate interference is present.
- Part 2 - The ADCP compares the RSSI value at high gain versus low gain. These values give the noise floor for RSSI. A high noise floor indicates possible interference or a hardware problem. A low difference between high and low RSSI values can indicate a problem in the demodulator, receiver, or RSSI switching circuitry.

- Part 3 - The ADCP displays the demodulator DAC values.

```
>PT3

Correlation Magnitude: Wide Bandwidth

               Lag  Bm1  Bm2  Bm3  Bm4
                 0  255  255  255  255
                 1  169  175  167  179
                 2   49   55   54   58
                 3   26   20   19    8
                 4   20   17   24   29
                 5   14   13   14   23
                 6    8    4   13    8
                 7    6    1   10    1

  High Gain RSSI:    43   41   40   42
   Low Gain RSSI:    19   19   17   18

  SIN Duty Cycle:    52   50   52   51
  COS Duty Cycle:    49   50   51   51

Receive Test Results = $0000 .... PASS
```

PT3 failure description - You can determine beam failure results ($>0, see "PT Test Results Error Codes," page 63) by the individual bit settings:

Table 17: PT3 Failure

Bit #	PT3 Failure Description
0	Low Correlation – Correlation at lag 1 is <70% (130 counts).
1	High Correlation - A correlation at lag 7 or above is >63 counts.
2	High Noise Floor - Noise floor for high gain is >59.
3	Low Differential Gain – Noise floor difference between high and low gains is less than 5 dB (10 counts).

NOTE. A functional ADCP may fail high correlation or high noise floor when this test is run in air due to interference. This test should be run in the deployed environment to achieve good results.

PT4 - Transmit Path

This test displays transmit path characteristics. During the test, the ADCP pings and measures the resulting transmit current and voltage. For example:

```
>PT4
IXMT    =      2.0 Amps rms
VXMT    =     74.0 Volts rms
   Z    =     37.6 Ohms
Transmit Test Results = $0 ... PASS
```

NOTE. The ADCP should be in water during this test to get valid test results.

PT4 failure description - You can determine failure results ($>0 see "PT Test Results Error Codes," page 63) by the individual bit settings:

Table 18: PT4 Failure

Bit #	PT4 Failure Description
0	ADC TIMEOUT ERROR - The DSP Board ADC was not ready for reading when the CPU was ready to read the ADC.
1	TRANSMIT TIMEOUT - The DSP Board never indicated completion of transmission.
2	SAMPLE TIMEOUT - The DSP Board never indicated completion of sampling.
3	LCA REGISTERS CORRUPTED - The DSP Board timing registers lost their value after pinging.
4	OVER-CURRENT SHUTDOWN
5	OVER-TEMPERATURE SHUTDOWN
6	INCORRECT TRANSDUCER IMPEDANCE - Impedance (Vxmt / Ixmt) was too high (>200Ω) or too low (<20Ω).
7	LOW TRANSMIT VOLTS AND/OR CURRENT - Transmit voltage was too low (Vxmt <10V) and/or transmit current too low (Ixmt <0.1A).

NOTE. Transducer should be in water when running this test.

The test failure example shown below is what you would see for a missing or improperly attached transmit cable (see the WorkHorse Technical Manual – Troubleshooting section).

```
>pt4

IXMT    =      0.0 Amps rms  [Data= 0h]
VXMT    =     19.3 Volts rms [Data=4ch]
   Z    =    999.9 Ohms
Transmit Test Results = $C0 ... FAIL
>
```

PT5 - Electronics Wrap Around

This test sets up the ADCP in a test configuration in which the test output lines from the DSP Board timing generator are routed directly to the Receiver board. The receiver then processes this signal. The test output signal sends a certain correlation pattern when processed. The ideal pattern is as follows.

```
  0   0   0   0
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
255 255 255 255
  0   0   0   0
  0   0   0   0
  0   0   0   0
255 255 255 255
```

Acceptable deviations from this pattern are due to deviations in sampling bandwidth and demodulator low-pass filter bandwidth variations. For example:

```
>PT5
13  13  13  13
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
0   0   0   0
255 255 255 255
13  13  13  13
13  13  13  13
0   0   0   0
255 255 255 255
Electronics Test Results = $0000
```

PT5 results description - Test failures indicate possible problems with the Receiver or DSP boards. You can determine failure results ($>0 see "PT Test Results Error Codes," page 63) by the individual bit settings:

Table 19: PT5 Results

Bit #	PT5 Results Description
28	BEAM 1 STATUS - A high value (normally 255) was <254, or a low value (normally 0) was >20.
24	BEAM 2 STATUS - See Bit 28.
20	BEAM 3 STATUS - See Bit 28.
16	BEAM 4 STATUS - See Bit 28.
12	BEAM 5 STATUS - See Bit 28.
ALL	RECEIVER TIMEOUT – The CPU never received a "processing done" signal from the receiver.

PT6 - Receive Bandwidth

This test measure the receive bandwidth of the system. The bandwidth varies with system frequency and the WB command setting.

```
>PT6
Receive Bandwidth:
    Sample      bw    bw    bw    bw    bw
      rate  expect   Bm1   Bm2   Bm3   Bm4
       307     120    91    93    88    88 Khz
   results          PASS  PASS  PASS  PASS
```

NOTE. The ADCP should be in water during this test to get valid test results.

Table 20: PT6 Receive Bandwidth Nominal Values

Bandwidth setting	WB command	150kHz	300 kHz	600 kHz	1200 kHz
Broad	0	45	79	200	316
Narrow	1	12	14	40	112

NOTE. Beam fails if <50% or >125% of nominal value.

PT7 - RSSI Bandwidth

This test checks the RSSI filter circuits are working. Values listed are the indicated RSSI sampled at 1-ms intervals after a “listen” ping.

```
>PT7
RSSI Time Constant:

RSSI Filter Strobe 1 =   38400 Hz
  time   Bm1   Bm2   Bm3   Bm4
  msec  cnts  cnts  cnts  cnts
     1     6     6     7     8
     2    11    12    14    15
     3    15    16    19    20
     4    20    21    23    25
     5    23    24    27    28
     6    26    27    30    31
     7    28    29    32    33
     8    30    31    34    35
     9    32    33    36    37
    10    34    35    37    38
   nom    43    43    42    43

result    PASS  PASS  PASS  PASS
>
```

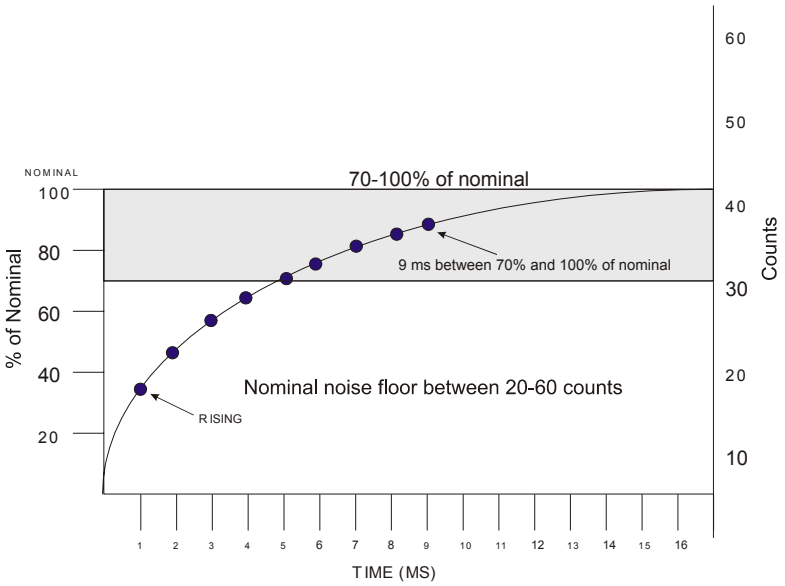


Figure 8. PT7 RSSI Bandwidth Test

Criteria for failure. Any one of the following conditions will flag failure for the beam:

- Nominal noise floor <20 or >60
- Counts for ms 1 through 4 not rising
- 9th ms sample not between 70 and 100% of nominal counts

2.7 Recorder Commands

The following paragraphs list all the WorkHorse ADCP recorder commands.

2.7.1 Available Recorder Commands

This section lists the available Recorder commands.

```
>r?
Available Commands:

RA ----------------------- Number of Deployments Recorded
RB ----------------------- Recorder Built-In-Test
RD ----------------------- Open/Close Deployment File
RE ----------------------- Recorder Erase
RF ----------------------- Recorder Space used/free (bytes)
RI 1 --------------------- Auto Increment Deployment File
RN  12345 ---------------- Set Deployment Name
RR ----------------------- Recorder diRectory
RS ----------------------- Recorder Space used/free (Mb)
RY ----------------------- Upload Recorder Files to Host
R? ----------------------- Display Recorder Commands

>
```

RA - Number of Deployments

Purpose Shows the number of deployments recorded on the internal recorder.

Format RA

Recommended Setting. Use as needed.

Description RA lists the number of deployments recorded on the optional internal recorder.

RB - Recorder Built-In Test

Purpose Tests the recorder.

Format RB

Recommended Setting. Use as needed. The recorder test is included in the PA command.

Description RB tests the recorder RAM, detects the number of memory cards, checks communication, and checks recorder functions using non-destructive methods.

Example See below.

```
>rb?
RECORDER TESTS:
  PC Card #0.............................NOT DETECTED
  PC Card #1.............................DETECTED
    Card Detect..........................PASS
    Communication........................PASS
    DOS Structure........................PASS
    Sector Test (Short)..................PASS

Recorder tests complete.
```

RD - Create Recorder File

Purpose: Opens a new deployment file or closes a currently open deployment file.

Format: RDxxxxxx

Range: xxxxxx = OPEN or CLOSE – see description

Description: RDOPEN creates a new recorder deployment file with the next increment for the current file name being used (see the "RN – Set Deployment Name," page 74 for information on setting the deployment name). If a file is currently open then the RDOPEN command will cause the currently open file to close and then will open a file with the same name but the next increment number.

Example: If the deployment file _ RDI _ 000.000 was currently open and the RD command was sent then; first, the file _ RDI _ 000.000 would be closed; and second, the file _ RDI _ 001.000 would be opened. The RDCLOSE command will close the currently open file.

CAUTION. Deployment files are not closed automatically when using the RI0 command. Deployment files must be manually closed using the RDCLOSE command **before** removing the recorder board from the WorkHorse ADCP. **Failure to do this will result in the loss of the deployment data on the recorder.**

NOTE. After the RD OPEN command is sent, a Break will be necessary before the CF command can be used to reconfigure the outputs.

Example: The RDOPEN command is sent. Even after the RDCLOSE command is sent it is not possible to set CFxxxx1. Once a break is sent, the CF command can be set to enable recording.

```
>cf?
CF= 11111 ------Flow Ctrl (EnsCyc:PngCyc:Binry:Ser:Rec)
>CF11101 ERR:  014:  RD COMMAND MUST BE SET TO 0 TO ENABLE RECORDER
```

RE – Erase Recorder

Purpose Erases/initializes recorder memory.

Format RE ErAsE

Description RE ErAsE erases the recorder memory. This command *is* case sensitive.

Recommended Setting. Use as needed.

Example See below.

```
>RE ErAsE
[ERASING...]
```

RF – Recorder Free Space (Bytes)

Purpose Lists the amount of used and free recorder space in bytes.

Format RF

Description RF lists the amount of recorder space used and free in bytes.

Recommended Setting. Use as needed.

Example See below

```
>RF
RF = 0,10407936 -------- REC SPACE USED (BYTES), FREE (BYTES)
```

This shows the WorkHorse ADCP contains a 10-MB recorder.

RI – Deployment Auto Increment

Purpose: Enables or Disables the deployment file increment.

Format: RIn

Range: n = 0 or 1 (0 = Append, 1 = New file)

Default: RI1

Recommended Setting. The default setting for this command is recommended for most applications.

Description: RI1 commands the recorder to start a new deployment file on the recorder whenever a deployment has been started (CS command has been sent). RI0 commands the recorder to append to the currently open deployment file on the recorder whenever a deployment is started (CS command has been sent).

NOTE. The ensemble number always initializes to ensemble 1. This means when the auto increment has been disabled (RI0) and a break has been sent to stop the current WorkHorse ADCP deployment that when the CS command is sent the next ensemble will be ensemble 1 and will be appended to the same deployment file.

Example: The RI0 command has been used and the CS command has been sent. The WH ADCP has collected 101 ensembles. The user now sends a break and uses the CE command to recover ensemble 101 from the buffer (see "CE - Retrieve Most Recent Data Ensemble," page 37). The user then sends the CS command to start the deployment again. The deployment will start again and the next ensemble written to the same deployment file will be ensemble number 1, not ensemble 102. This will not affect any TRDI software programs.

Example SC Deployment Scenario using the RI0 command

The following example describes how to use your WorkHorse ADCP in a Self-Contained deployment with TRDI Software when you do not want the deployment file number to increment.

Use TRDI's Windows software program *WinSC* to plan, set the clock, calibrate the compass, and test the ADCP. To actually start your deployment you will have to use TRDI's Windows software program *BBTalk*. The following steps outline the procedure.

NOTE. For more information on how to use WinSC, see the WinSC User's Guide. For information on how to use *BBTalk*, see the RDI Tools User's Guide.

a. Use *WinSC's* Deployment Wizard to plan your deployment, set the clock, calibrate the compass, and test the WorkHorse ADCP.

b. When you reach the **Deploy the ADCP** box, click **Cancel**

c. Click **Save As** and name your deployment file (Do *not* close *WinSC*).

d. Locate the directory that your deployment setup has been saved to.

e. Open the *.WHP command text file in a text editor.

f. Delete the command CR1.

g. Exit and save command file.

h. Open the TRDI software program *BBTalk* and setup the software for the proper comport that the WorkHorse ADCP is connected to.

i. Click the **B** on the toolbar to send a break to the ADCP.

j. Type the command CR1 and press enter.

k. Type the command RI0 and press enter.

l. Type the command CK and press enter.

m. Once you receive the confirmation that your parameters have been saved, exit and close the *BBTalk* program.

n. Return to the *WinSC* program.

o. On the **Functions** menu**,** click **Deploy**.

The WorkHorse ADCP will now be deployed and the RI command will have already been sent and saved in the ADCP.

CAUTION. Deployment files are not closed automatically when using the RI0 command. Deployment files must be manually closed using the RDCLOSE command **before** removing the recorder board from the WorkHorse ADCP. **Failure to do this will result in the loss of the deployment data on the recorder.**

RN – Set Deployment Name

Purpose	Sets the deployment name used for future deployments.
Format	RN AAAAA
Default	RN _RDI_

Recommended Setting. Use as needed.

Description RN sets the deployment name to be used for any future deployments. The deployment name must be exactly five characters in length, and may contain letters, numbers, or the underscore (i.e. "_") character. If no deployment name is specified, a default of "_ RDI_" is used. The deployment name is used as part of the DOS file name for data files stored on the recorder. For example, the file "_RDI_000.000" would contain data for the first deployment named "_RDI_" (the 000 in the filename indicates the first deployment). The ".000" file extension indicates that this is the first file in the deployment sequence. A ".001" extension will be used if the deployment spills over onto the second PCMCIA card in the recorder. Each PCMCIA card is set up as a separate DOS disk drive with its own DOS file structure. Deployments that are recorded completely on a single PCMCIA device will only have the ".000" file extension.

RR – Show Recorder File Directory

Purpose Lists the files on the recorder in the style of a DOS directory listing.

Format RR

Recommended Setting. Use as needed.

Description RR lists the files stored on the recorder in the form of a DOS directory listing. Each PCMCIA device is listed as a separate drive.

RS - Recorder Free Space (Megabytes)

Purpose Lists the amount of used and free recorder space in megabytes.

Format RS

Recommended Setting. Use as needed.

Description RS lists the amount of recorder space used and free in megabytes.

Example See below

```
>RS
RS = 000,010 -------- REC SPACE USED (MB), FREE (MB)
```

This shows the WorkHorse ADCP contains a 10-MB recorder.

RY – Upload Recorder Files

Purpose — Uploads recorder data to a host computer using standard YMODEM protocol.

Format — RY

Recommended Setting. Use as needed.

Description — RY uploads the entire contents of the recorder via the serial interface to a host computer using the standard YMODEM protocol for binary file transfer. Any communications program that uses the YMODEM protocol may be used to upload the recorder data. The data is transferred to the host and stored as binary files. This command may be used to recover deployment data without opening the pressure case of the WorkHorse ADCP unit.

Alternatively, the PCMCIA recorder cards may be removed from the unit and placed into a PCMCIA slot in any MS-DOS based computer so equipped. The data files may then be accessed in the same manner as from any other disk drive.

CAUTION. Do not use Windows® to erase the files on the PCMCIA card. Windows® sometimes creates hidden files, which will cause issues for the ADCP at the next deployment. Place the PCMCIA card in the ADCP and use the RE command to erase the card.

2.8 Timing Commands

The following commands let you set the timing of various profiling functions.

2.8.1 Available Timing Commands

This section lists the available Timing commands.

```
>t?
TB = 00:00:00.00 --------- Time per Burst (hrs:min:sec.sec/100)
TC = 00000 --------------- Ensembles Per Burst (0-65535)
TE = 01:00:00.00 --------- Time per Ensemble (hrs:min:sec.sec/100)
TF = **/**/**,**:**:** --- Time of First Ping (yr/mon/day,hour:min:sec)
TG = ****/**/**,**:**:** - Time of First Ping (CCYY/MM/DD,hh:mm:ss)
TP = 01:20.00 ------------ Time per Ping (min:sec.sec/100)
TS = 06/12/18,13:24:30 --- Time Set (yr/mon/day,hour:min:sec)
TT = 2006/12/18,13:24:30 - Time Set (CCYY/MM/DD,hh:mm:ss)
TX = 00:00:00 ------------ Buffer Output Period: (hh:mm:ss)
>
```

2.8.2 Timing Command Descriptions

TB - Time Per Burst

Purpose — Sets the interval between "bursts" of pings.

Format — TB hh:mm:ss.ff

Range —
hh = 00 to 23 hours
mm = 00 to 59 minutes
ss = 00 to 59 seconds
ff = 00 to 59 hundredths of seconds

Recommended Setting. Special applications only.

Description — The TB and TC commands work together to allow the ADCP to sample in a "burst mode." In some applications, it is desirable for the ADCP to ping for a short period of time at a high ping rate ("burst"), wait for a set period of time, and then repeat the process. You also must set the time per ensemble, time between pings, and number of pings per ensemble.

Example — Deployment timing example:

```
TB 01:00:00.00   (time per burst)
TC 20            (ensembles per burst)
TE 00:00:01.00   (time per ensemble)
TP 00:00.20      (time between pings)
WP 2             (pings per ensemble)
```

The ADCP will average two pings (WP-command) 0.2 seconds apart (TP-command). It then sends the ensemble to the recorder or through the I/O cable. This process is repeated once a second (TE-command) for a total of

twenty ensembles (TC-command). After the 20th ensemble is processed, the ADCP sleeps for one hour (TB-command) from the time of the first ping of the first ensemble until the second burst begins.

TC - Ensemble per Burst

Purpose	Sets the number of ensembles per burst.
Format	TC*nnnnn*
Range	0 to 65535 ensembles per burst
Default	TC0

Recommended Setting. Special applications only.

Description — Setting TC to zero disables the burst mode (i.e., TB-command inactive). See the TB-command for details on how these two commands interact.

TE – Time Per Ensemble

Purpose	Sets the minimum interval between data collection cycles (data ensembles).
Format	TEhh:mm:ss.ff
Range	*hh* = 00 to 23 hours *mm* = 00 to 59 minutes *ss* = 00 to 59 seconds *ff* = 00 to 99 hundredths of seconds
Default	TE01:00:00.00

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description — During the ensemble interval set by TE, the WorkHorse ADCP transmits the number of pings set by the WP-command. If TE = 00:00:00.00, the WorkHorse ADCP starts collecting the next ensemble immediately after processing the previous ensemble.

Example — TE01:15:30.00 tells the WorkHorse ADCP to collect data ensembles every 1 hour, 15 minutes, 30 seconds.

NOTES.

1. The WorkHorse ADCP automatically increases TE if (WP x TP > TE).
2. The time tag for each ensemble is the time of the first ping of that ensemble.

TF – Time of First Ping

Purpose — Sets the time the WorkHorse ADCP wakes up to start data collection.

Format — TF*yy/mm/dd, hh:mm:ss*

Range

yy	= year 00-99
mm	= month 01-12
dd	= day 01-31 (leap years are accounted for)
hh	= hour 00-23
mm	= minute 00-59
ss	= second 00-59

Recommended Setting. Set using *WinSC*.

Description — TF delays the start of data collection. This lets you deploy the WorkHorse ADCP in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the WorkHorse ADCP to start pinging, TF is tested for validity. If valid, the WorkHorse ADCP sets its alarm clock to TF, goes to sleep, and waits until time TF before beginning the data collection process.

Example — If you want the exact time of the first ping to be on November 23, 1992 at 1:37:15 pm, you would enter TF92/11/23, 13:37:15. Do not enter a TF-command value if you want the WorkHorse ADCP to begin pinging immediately after receiving the CS-command (see notes).

NOTES.

1. Although you may send a TF-command to the WorkHorse ADCP, you also must send the CS-command before deploying the WorkHorse ADCP.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TF time.

TG – Time of First Ping (Y2k Compliant)

Purpose	Sets the time the WorkHorse ADCP wakes up to start data collection.
Format	TG*ccyy/mm/dd, hh:mm:ss*
Range	*cc* = century 19 - 20 *yy* = year 00 - 99 *mm* = month 01 - 12 *dd* = day 01 - 31 (leap years are accounted for) *hh* = hour 00 - 23 *mm* = minute 00 - 59 *ss* = second 00 – 59

Recommended Setting. Set using *WinSC*.

Description TG delays the start of data collection. This lets you deploy the WorkHorse ADCP in the Standby mode and have it automatically start data collection at a preset time (typically used in battery operated instruments). When the command is given to the WorkHorse ADCP to start pinging, TG is tested for validity. If valid, the WorkHorse ADCP sets its alarm clock to TG, goes to sleep, and waits until time TG before beginning the data collection process.

Example If you want the exact time of the first ping to be on November 23, 2000 at 1:37:15 pm, you would enter TG 2000/11/23, 13:37:15. Do not enter a TG-command value if you want the WorkHorse ADCP to begin pinging immediately after receiving the CS-command (see notes).

NOTES.

1. Although you may send a TG -command to the WorkHorse ADCP, you also must send the CS-command before deploying the WorkHorse ADCP.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the wake-up time.
3. Sending a <BREAK> clears the TG time.

TP – Time Between Pings

Purpose	Sets the *minimum* time between pings.
Format	TP*mm:ss.ff*
Range	*mm* = 00 to 59 minutes *ss* = 00 to 59 seconds *ff* = 00 to 99 hundredths of seconds
Default	TP01:20.00

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description The WorkHorse ADCP interleaves individual pings within a group so they are evenly spread throughout the ensemble.

During the ensemble interval set by TE, the WorkHorse ADCP transmits the number of pings set by the WP- command. TP determines the spacing between the pings. If TP = 0, the WorkHorse ADCP pings as quickly as it can based on the time it takes to transmit each ping plus the overhead that occurs for processing. Several commands determine the actual ping time (WF, WN, WS, and actual water depth).

Example TP00:00.10 sets the time between pings to 0.10 second.

NOTE. The WorkHorse ADCP automatically increases TE if (WP x TP) > TE.

TS – Set Real-Time Clock

Purpose	Sets the WorkHorse ADCP's internal real-time clock.
Format	TS*yy/mm/dd, hh:mm:ss*
Range	*yy* = year 00-99 *mm* = month 01-12 *dd* = day 01-31 *hh* = hour 00-23 *mm* = minute 00-59 *ss* = second 00-59

Recommended Setting. Set using *BBTalk*, *WinSC*, *VmDas*, or *WinRiver*.

Example TS98/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 1998.

NOTES.

1. When the WorkHorse ADCP receives the carriage return after the TS- command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the real-time clock.

TT – Set Real-Time Clock (Y2k Compliant)

Purpose	Sets the WorkHorse ADCP's internal real-time clock.	
Format	TT*ccyy/mm/dd, hh:mm:ss*	
Range	*cc*	= century 19 - 20
	yy	= year 00 - 99
	mm	= month 01 - 12
	dd	= day 01 - 31
	hh	= hour 00 - 23
	mm	= minute 00 - 59
	ss	= second 00 - 59

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Example TT2000/06/17, 13:15:00 sets the real-time clock to 1:15:00 pm, June 17, 2000.

NOTES.

1. When the WorkHorse ADCP receives the carriage return after the TS- command, it enters the new time into the real-time clock and sets hundredths of seconds to zero.
2. If the entry is not valid, the WorkHorse ADCP sends an error message and does not update the real-time clock.

TX – Buffered Output Period

Purpose	Sets the minimum interval between buffered data outputs.
Format	TX*hh*:*mm*:*ss*
Range	*hh* = 00 to 23 hours
	mm = 00 to 59 minutes
	ss = unsupported
Default	TX00:00:00

Recommended Setting. This command is designed for use with the NEMO Wave Processing Module. This command may also be used for other special applications.

CAUTION. Values from TX 00:00:01 to TX 00:00:59 are unsupported.

Avoid setting TX to values between the default, TX 00:00:00 and TX 00:01:00.

Description Setting TX to zero disables the buffered output mode.

NOTES.

1. No data will be output during the collection of WAVES data.
2. Ensemble data must be in PD0 binary format.
3. The TX command will always go to the default setting after a break.

2.9 Water Profiling Commands

The following commands define the criteria used to collect the water-profile data.

2.9.1 Standard Water Profiling Commands

This section lists the most often used Water Profiling commands.

```
>w?
WA = 050,1 --------------- False Target Threshold (Max) (0-255 counts)
WB = 0 ------------------- Bandwidth Control (0=Wid,1=Nar)
WC = 064 ----------------- Correlation Threshold
WD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
WE = 2000 ---------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0044 ---------------- Blank After Transmit (cm)
WI = 0 ------------------- Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
WK = 0000 ---------------- Mode 11,12 Depth Cell Size Override (cm) [0=Use WS]
WL = 001,005 ------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WN = 030 ----------------- Number of depth cells (1-255)
WP = 00045 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0100 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WU = 0 ------------------- Ping Weighting (0=Box,1=Triangle)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
WW = 004 ----------------- Mode 1 Pings before Mode 4 Re-acquire
WX = 999 ----------------- Mode 4 Ambiguity Vel (cm/s radial)
WZ = 010 ----------------- Mode 5 Ambiguity Velocity (cm/s radial)
>
```

WA - False Target Threshold Maximum

Purpose	Sets a false target (fish) filter.
Format	WA*nnn,bbb*
Range	*nnn* = 0 to 255 counts (255 disables this filter) *bbb* = 0 to 255 bins (255 disables this filter) (optional)
Default	WA050,1

Recommended Setting. The default setting for this command is recommended for most applications.

Description The ADCP uses the WA-command to screen water-track data for false targets (usually fish). The first parameter in the WA command sets the maximum difference between echo intensity readings among the four profiling beams. If the WA threshold value is exceeded, the ADCP rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam). This usually occurs when fish pass through one or more beams.

The optional second parameter of the WA command sets the starting bin number of the fish rejection screening. Setting the second parameter to 0 is the same as setting it to 1 (i.e. all bins

will be screened for fish). Setting the second parameter to > WN and/or 255 will effectively disable fish rejection screening. Setting the first parameter without the optional second parameter will reset it to the default of 1.

NOTE. A WA value of 255 turns off this feature.

WB - Mode 1 Bandwidth Control

Purpose — Sets profiling mode 1 bandwidth (sampling rate). Smaller bandwidths allow the ADCP to profile farther, but the standard deviation is increased by as much as 2.5 times.

Format — WB*n*

Range — *n* = 0 (Wide), 1 (Narrow)

Default — WB0

Recommended Setting. The default setting for this command is recommended for most applications.

Description — See table below.

Table 21: Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	High	Low	Low
1 = Narrow (6.25%)	Low	High	High

WC - Low Correlation Threshold

Purpose — Sets the minimum threshold of water-track data that must meet the correlation criteria.

Format — WC*nnn*

Range — *nnn* = 0 to 255 counts

Default — WC064

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The ADCP uses WC to screen water-track data for the minimum acceptable correlation requirements. The nominal (maximum) correlation depends on system frequency and depth cell size (WS). WC sets the threshold of the correlation

below, which the ADCP flags the data as bad and does not average the data into the ensemble.

NOTE. The default threshold for all frequencies is 64 counts. A solid target would have a correlation of 255 counts.

WD – Data Out

Purpose — Selects the data types collected by the ADCP.

Format — WD *abc def ghi*

Range — Firmware switches (see description)

Default — WD 111 100 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description — WD uses firmware switches to tell the ADCP the types of data to collect. The ADCP always collects header data, fixed and variable leader data, and checksum data. Setting a bit to one tells the ADCP to collect that data type. The bits are described as follows:

a = Velocity	*d* = Percent good	*g* = Reserved
b = Correlation	e = Status	*h* = Reserved
c = Echo Intensity	*f* = Reserved	*I* = Reserved

Example — WD 111 100 000 (default) tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent-good.

NOTES.

1. Each bit can have a value of one or zero. Setting a bit to one means output data, zero means suppress data.
2. If WP = zero, the ADCP does not collect water-profile data.
3. Spaces in the command line are allowed.
4. Status data is not used, as it does not mean anything.

WE - Error Velocity Threshold

Purpose — Sets the maximum error velocity for good water-current data.

Format — WE*nnnn*

Range — *nnnn* = 0 to 9999 mm/s

Default — WE2000

CAUTION. The default setting is set purposely high. We recommend extreme caution and testing before changing this setting. **Data rejected by this command is lost and cannot be regained.**

Description — The WE-command sets a threshold value used to flag water-current data as good or bad. If the ADCP's error velocity value exceeds this threshold, it flags data as bad for a given depth cell. WE screens for error velocities in both beam and transformed-coordinate data. Setting the WE command to zero (WE0) disables error velocity screening.

WF – Blank after Transmit

Purpose — Moves the location of first depth cell away from the transducer head to allow the transmit circuits time to recover before the receive cycle begins.

Format — WF*nnnn*

Range — *nnnn* = 0 to 9999 cm

Default — WF0704 (75 kHz), WF0352 (150 kHz), WF0176 (300 kHz), WF0088 (600 kHz), WF0044 (1200 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description — WF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the WorkHorse ADCP transmit circuits time to recover before beginning the receive cycle. In effect, WF blanks out bad data close to the transducer head, thus creating a depth window that reduces unwanted data in the ensemble.

NOTES.

1. The distance to the middle of depth cell #1 is a function of blank after transmit (WF), depth cell size (WS), and speed of sound. The fixed leader data contains this distance.
2. Small WF values may show ringing/recovery problems in the first depth cells that cannot be screened by the WorkHorse ADCP.

WI - Clip Data Past Bottom

Purpose — Allows the ADCP to flag velocity data from beyond the bottom as bad.

Format — WIn

Range — n = 0 (off), 1 (on)

Default WI0

Recommended Setting. The default setting for this command is recommended for most applications.

Description When the WI-command is set to WI0 (default), the ADCP sends/records all velocity data readings even when the ADCP determines the data is beyond the bottom. WI1 tells the ADCP to flag data determined to be beyond the bottom as bad (data value set to -32768 [8000h]).

WJ - Receiver Gain Select

Purpose Allows the ADCP to reduce receiver gain by 40 dB.

Format WJn

Range n = 0 (low), 1 (high)

Default WJ1

Recommended Setting. The default setting for this command is recommended for most applications.

Description WJ0 tells the ADCP to reduce receiver gain by 40 dB. This may increase data reliability in shallow-water applications where there is a high content of backscatter material. WJ1 (the default) uses the normal receiver gain.

WL - Water Reference Layer

Purpose Sets depth cell range for water-track reference layer averaging.

Format WLsss,eee

Range sss = Starting depth cell (0 to 128; 0 disables this feature)

eee = Ending depth cell (1 to 128)

Default WL1,5

Recommended Setting. The default setting for this command is recommended for most applications.

Description You can use the WL-command to lower the effects of transducer motion on present measurements for multiple-ping ensembles (WP > 1). The ADCP does this by averaging the velocities of a column of water and subtracting that average from each of the depth cell velocities. The ADCP accumulates the resulting average velocity and depth cell velocities. At the end on an ensemble, the ADCP adds the average reference velocity back to the normalized depth cell velocities. This results in

quieter data for depth cells in which there were few good samples.

WN – Number of Depth Cells

Purpose	Sets the number of depth cells over which the ADCP collects data.
Format	WN*nnn*
Range	*nnn* = 1 to 255 depth cells
Default	WN030

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description The range of the ADCP is set by the number of depth cells (WN) times the size of each depth cell (WS).

WP – Pings Per Ensemble

Purpose	Sets the number of pings to average in each data ensemble.
Format	WP*nnnnn*
Range	*nnnnn* = 0 to 16384 pings
Default	WP00045

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description WP sets the number of pings to average in each ensemble before sending/recording the data.

NOTES.

1. If WP = zero the ADCP does not collect water-profile data.
2. The ADCP automatically extends the ensemble interval (TE) if WP x TP > TE.

WQ - Sample Ambient Sound

Purpose	Samples ambient sound.
Format	WQn
Range	n = 0 (Off), 1 (On)
Default	WQ0

Recommended Setting. The default setting for this command is recommended for most applications.

Description When WQ is set to 1, the ADCP samples RSSI before the water ping. WQ uses an 8-meter blank and 8-meter depth cell before sending water-profiling pings.

WS – Depth Cell Size

Purpose Selects the volume of water for one measurement cell.

Format WS*nnnn*

Range See below

Default See below

	75 kHz	150 kHz	300 kHz	600 kHz	1200 kHz	2400 kHz
Range	80 to 3200 cm	40 to 3200 cm	20 to 1600 cm	10 to 800 cm	5 to 400 cm	5 to 200 cm
Default	WS1600	WS0800	WS0400	WS0200	WS0100	WS0050

Recommended Setting. Set using *WinSC*, *VmDas*, or *WinRiver*.

Description The ADCP collects data over a variable number of depth cells. WS sets the size of each cell in vertical centimeters.

NOTE. If you set WS to a value less than its minimum value or greater than its maximum value, the ADCP will accept the entry, but uses the appropriate minimum or maximum value. For example, if you enter WS1 for a 75 kHz system, the ADCP uses a value of 80 cm for WS. Similarly, if you enter WS8000, the ADCP uses a value of 3200 cm for WS.

WT - Transmit Length

Purpose Selects a transmit length different from the depth cell length (cell sampling interval) as set by the WS-command.

Format WT*nnnn*

Range *nnnn* = 0 to 3200 cm

Default WT0000

Recommended Setting. The default setting for this command is recommended for most applications.

Description When WT is set to zero, the transmit signal is set to the depth cell size (WS-command). This is the default setting. Setting WT allows selection of a transmit length different then the area depth cell size (sampling length).

WU - Ping Weight

Purpose: Selects the weight of each ping in an ensemble.

Format WUn

Range n = 0 (Box weighting), 1 (Triangle weighting)

Default WU0

Recommended Setting. The default setting for this command is recommended for most applications.

Description The WU command allows the user to choose the ensemble weighting method. WU0 selects Box weighting which is a simple average of the velocities in each ensemble. WU1 selects Triangle weighting, where the first and last velocities are weighted the least, and the middle velocity is weighted the most.

Example For an ensemble of 5 pings, the weights would appear as below.

Table 22: Ping Weights

	Ping 1	Ping 2	Ping 3	Ping 4	Ping 5
WU0	1	1	1	1	1
WU1	1/3	2/3	1	2/3	1/3

NOTE. The velocity reported for each ensemble is calculated as the sum of the weighted velocities divided by the sum of the weights.

WV – Ambiguity Velocity

Purpose Sets the radial ambiguity velocity.

Format WV*nnn*

Range *nnn* = 2 to 700 cm/s

Default WV175

Recommended Setting. It is strongly recommended that the WV command be left at its' default value of 175.

Description Set WV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Rule of thumb: Set WV to the maximum relative horizontal velocity between water-current speed and ADCP speed.

The WV command (ambiguity velocity setting) sets the maximum velocity that can be measured along the beam when

operating in water mode 1 (WM1). WV is used to improve the single-ping standard deviation. The lower the value of the WV command, the lower the single-ping standard deviation.

You are required to set the WV command based on the maximum apparent velocity (ADCP motion plus water speed). The following formula is used to determine the setting of the WV command: WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.2

NOTE. Note that the minimum setting of the WV command is WV002 and the maximum setting due to internal processing limitations is limited based on the setting of the bandwidth command, WB.

WV is limited to 330 cm/s in Narrow bandwidth mode (WB1), which increases the profiling range by 10% compared to Broad bandwidth mode (WB0).

When the WB command is set to WB0, the max value is WV700.

In either case, while you can set a value as low as 2 cm/s, this will likely cause ambiguity errors. TRDI recommends setting WV to ≥ 100cm/s for most applications.

Table 23: WV-command Maximum Setting (20 Degree)

WB Command	Bandwidth	WV (max cm/s)	Apparent Velocity (max cm/s)
0	25%	700	1,705
1	12%	330	804

Example

If the maximum expected ADCP velocity (vessel velocity) is 250 cm/s (≈5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set WV to 350 cm/s.

2.9.2 High Resolution Water Profiling

This section defines the optional High Resolution Water-Profiling commands used by the WorkHorse ADCP.

NOTE. High Resolution Water Profiling is a feature upgrade for other WorkHorse ADCPs (see "Feature Upgrades," page 5). The highlighted commands are included with the High Resolution Water Profiling upgrade.

```
>w?
WA = 050 ----------------- False Target Threshold (Max) (0-255 counts)
WB = 0 ------------------- Bandwidth Control (0=Wid,1=Nar)
WC = 064 ----------------- Correlation Threshold
WD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
WE = 2000 ---------------- Error Velocity Threshold (0-5000 mm/s)
WF = 0044 ---------------- Blank After Transmit (cm)
WI = 0 ------------------- Clip Data Past Bottom (0=OFF,1=ON)
WJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
WK = 0000 ---------------- Mode 11,12 Depth Cell Size Override (cm) [0=Use WS]
WL = 001,005 ------------- Water Reference Layer:  Begin Cell (0=OFF), End Cell
WM = 01 ------------------ Profiling Mode (1,5,8,11,12,15)
WN = 030 ----------------- Number of depth cells (1-255)
WO = 001,004 ------------- Mode 12 Params [subpings (1-100);time (1/100th sec)]
WP = 00045 --------------- Pings per Ensemble (0-16384)
WQ = 0 ------------------- Sample Ambient Sound (0=OFF,1=ON)
WS = 0100 ---------------- Depth Cell Size (cm)
WT = 0000 ---------------- Transmit Length (cm) [0 = Bin Length]
WU = 0 ------------------- Ping Weighting (0=Box,1=Triangle)
WV = 175 ----------------- Mode 1 Ambiguity Vel (cm/s radial)
WW = 004 ----------------- Mode 1 Pings before Mode 4 Re-acquire
WX = 999 ----------------- Mode 4 Ambiguity Vel (cm/s radial)
WZ = 010 ----------------- Mode 5 Ambiguity Velocity (cm/s radial)
>
```

WK – Depth Cell Size Override (Mode 11/12 Only)

Purpose	Determines the depth cell size for Mode 11 and Mode 12 profiling.
Format	WK*x*
Range	*x* = 0 to frequency dependent maximum for WS command.
Default	WK0000

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The WK command allows a depth cell size that is smaller than the minimum allowed by the WS command. If WK is set to other than zero it overrides the depth cell size selected by the WS command. If WK is set to zero the WS command takes precedence.

NOTE. This command is only available if the High Rate Ping feature or the High Resolution Water Modes feature is enabled. This command has no effect unless the WM command is set to either 11 or 12.

WM - Profiling Mode

Purpose — Selects the application-dependent profiling mode used by the ADCP.

Format — WM*n*

Range — *n* = 1, 5, 8, 11, 12, and 15 (see description)

Default — WM01

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The WM-command lets you select an application-dependent profiling mode. The chosen mode selects the types of pings transmitted. The ping type depends on how much the water-current is changing from ping-to-ping and from cell-to-cell.

Table 24: Water Modes

Mode	Description
WM1	Dynamic Sea State
WM5	Very Low Standard Deviation, used in low flow
WM8	Very Shallow Water, used in low flow
WM11	High Resolution Mode
WM12	High Rate Ping
WM15	Lowered ADCP (See note below)

CAUTION. Water Modes 5, 8, 11, and 12 were designed for 600 and 1200 kHz ADCPs only. Using these modes on other frequency ADCPs may be possible, but only at the user's risk.

CAUTION. When a WM1 or WM15 command is used in a command file, place it after the CR1 command and before any other commands to eliminate the risk of changing a previously sent parameter (see "Using Direct Commands to Deploy your ADCP," page 6).

For example, when the ADCP receives the WM15 command, the ADCP automatically changes several commands to LADCP appropriate values. It changes the water profile bandwidth to 6 % by setting WB and LW to 1, the number of water profile pings to 1 by setting WP and LP to 1, and the time per ensemble and time per ping to 1 second by setting TE 00:00:01.00 and TP 00:01.00 respectively.

Conversely, when the ADCP has been using WM15 and receives the WM1 command, the ADCP automatically changes the same command parameters to their factory default values (see Table 3, page 11 to view the WorkHorse ADCP factory defaults).

CAUTION. When the ADCP receives a WM1 or WM15 command, *the automatic command changes are transparent to the user*, who may require other bandwidth, number of pings, time per ensemble, and/or ping values.

NOTE. Water Mode 11 is included in the High Resolution Water Profiling feature upgrade.

Water Mode 12 is a separate feature upgrade for WorkHorse ADCPs.

Water Mode 15 is a separate feature upgrade for WorkHorse ADCPs.

NOTES. For general information on the Water Modes, see the *Principles of Operation: A Practical Primer* and the *WinRiver* User's Guide. For detailed information on each Water Mode, see the following Field Service Application Notes (FSAs).

FSA-004 – WM1
FSA-005 – WM5 and WM8
FSA-013 – WM11
FSA-014 – WM12

FSAs are available for download at www.rdinstruments.com, Customer Support page.

WO – Mode 12 Parameters

Purpose	Controls the behavior of Mode 12 water profiling.
Format	WO*x,y*
Range	*x* = 1 to 100 sub-pings
	y = 0 to 999 hundredths of seconds
Default	WO001,004

Recommended Setting. Special applications only.

Description: The WO command governs the behavior of Mode 12 water profiling. In Mode 12, a number of sub-pings are transmitted very rapidly and their results are averaged internally to form a single Mode 12 ping. The number of sub-pings is determined by the *x* parameter. The *y* parameter sets the time between sub-pings in hundredths of a second.

NOTE. This command is only available when the High Rate Ping feature is enabled. This command has no effect unless the WM command is set to WM12.

WZ - Mode 5 Ambiguity Velocity

Purpose	Sets the minimum radial ambiguity for profiling Mode 5 (WM5), Mode 8 (WM8) and Mode 11 (WM11) Ambiguity Velocity.
Format	WZ*nnn*
Range	*nnn* = 3 to 80 cm/s
Default	WZ010

Recommended Setting. The default setting for this command is recommended for most applications.

Description Allows for very high resolution (small bins) with very low standard deviation.

The maximum value at which WM5 will work is related to bottom track depth. The larger the WZ value, the shallower the water has to be.

3 Advanced Commands

The following sections describe the advanced commands available for the WorkHorse ADCP series ADCPs.

3.1 Sound Velocity Smart Sensor Commands

The ADCP uses these commands for Sound Velocity Smart Sensor (SVSS) applications.

3.1.1 Available Sound Velocity Smart Sensor Command

```
>d?
Available Commands:

DW  0 -------------------- Current ID on RS-485 Bus
DB 411 ------------------- RS-485 Port Control (Baud; N/U; N/U)
DX ----------------------- Set SVSS to RAW Mode
DY ----------------------- Set SVSS to REAL Mode
DZ ----------------------- Get Single SCAN from SVSS
DS 1495 0 ---------------- Load SpeedOfSound with SVSS Sample (BITResult)
D? ----------------------- Display SVSS Commands

>
```

3.1.2 Sound Velocity Smart Sensor Command Descriptions

DB - RS-485 Port Control

Purpose	Change the communication parameters of the RS-485 bus.
Format	DBxyz
Range	x = 0 to 7 Baud Rate, See "CB - Serial Port Control," page 34. y =l to 5 Unused z =l to 2 Unused
Default	DB411

Recommended Setting. Use as needed.

Description — This command changes the communication parameters of the RS-485 bus. Currently only the Baud Rate is changed, but all parameters are still required. Set the baud rate to match the CB command (see "CB - Serial Port Control," page 34).

CAUTION. If the DB command is not set to the same baud rate as the CB command, then the Master/Slave triggering is not reliable. When changing the DB command, confirm the change by immediately following the DB change with a CK command (see "CK - Keep Parameters," page 40).

NOTE. The DB command is not affected by the CR command once the CK command has been sent (see "CR – Retrieve Parameters," page 43).

DS - Load SpeedOfSound with SVSS Sample (BIT Result)

Purpose — Load the SpeedOfSound variable with a single real scan from the SVSS.

Format — DS

Recommended Setting. Use as needed.

Description — This command loads the SpeedOfSound variable with a measured value from the SVSS, in a manner similar to the manner the variable is loaded during deployment. The EZ command must be issued prior to this command or the function will be bypassed. Set the EZ command to EZ3xxxxxx. The three enables communication with the SVSS. Upon successful completion of the function call, the SpeedOfSound variable will contain the new value. Any errors in the function will result in the BIT Result (Table 33, page 134) = xxxxxlxx xxxxxxxx which is displayed after the value.

DW - Current ID on RS-485 Bus

Purpose — Change the device ID sent out before attempting to communicate.

Format — DWx

Range — x = 0 to 31

Default — DW0

Recommended Setting. Use as needed.

Description — This commands sets the RS-485 Bus ID and sends the ID out onto the bus with the parity forced high. This wakes up the slave device for communications.

DX - Set SVSS to RAW Mode

Purpose — Set the SVSS to Raw mode.

Format — DX

Recommended Setting. Use as needed.

Description — This command sends “RA” out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to RAW. RAW data is columnar uncalibrated counts.

DY - Set SVSS to REAL Mode

Purpose Set the SVSS to Real mode.

Format DY

Recommended Setting. Use as needed.

Description This command sends "RE" out on the RS-485 bus. If the SVSS is listening, it will change its data output mode to REAL. REAL data is in units of m/s and the form XXXX.XX

DZ - Get Single SCAN from SVSS

Purpose This command gets a single scan of data from the SVSS.

Format DZ

Recommended Setting. Use as needed.

Description This command sends "s" out on the RS-485 bus. If the SVSS is listening, it will respond (-23ms later) with one scan of data. The data format will be determined by the last format command ("DX" or "DY") sent to the SVSS. The data will be echoed back by the ADCP.

3.2 Waves Commands

NOTE. Waves is a feature upgrade for WorkHorse ADCPs (see "Feature Upgrades," page 5).

NOTE. Waves requires version 16.xx firmware to run. Water Modes WM5, WM11 & WM12 can be used with WAVES modes. The caveat is that more than usual care must be taken in the set-ups.

For information on how to use the Waves commands, see the Waves User's Guide.

3.2.1 Available Waves Commands

```
>h?
Available Commands:

HA 255 ------------------- Waves False Target Threshold (Fish Rejection)
HB 05 -------------------- Number of Automatically Choosen Bins (20 Max)
HD 111000000 ------------- Waves Selected Data (Vel;Pres;Surf HPR;; ;;)
HF 00000 ----------------- Waves Flow Ctrl (Res;Res;Res;Ser;Rec)
HP 0000 ------------------ Number of Pings per Record
HR 01:00:00.00 ----------- Time between Wave Bursts (hh:mm:ss.ff)
HS 001,010,021,022,023 --- Bins selected for Directional wave data recording
HT 00:00:00.50 ----------- Time between Wave Pings (hh:mm:ss.ff)
HV 001,010,021,022,023 --- Bins selected for Velocity Spectrum data re-
cording
H? ----------------------- Display Waves Menu Help

>
```

3.2.2 Waves Command Descriptions

HA – Waves False Target Threshold

Purpose	Sets a false target (fish) filter.
Format	HA*nnn*
Range	*nnn* = 0 to 255 counts (255 disables this filter)
Default	HA255

Recommended Setting. The default setting for this command is recommended for most applications.

Description The ADCP uses the HA-command to screen water-track data for false targets (usually fish). HA sets the maximum difference between echo intensity readings among the four profiling beams. If the HA threshold value is exceeded, the ADCP rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam). This usually occurs when fish pass through one or more beams.

HB – Automatically Chosen Bins for Wave Processing

Purpose — Set the number of automatically chosen bins for doing Directional Wave Spectra.

Format — HB*n*

Range — *n* = 1 to 20 bins (*n* = 0 disables auto-bin selection)

Default — HB5

Recommended Setting. The default setting for this command is recommended for most applications.

Description — Bins are selected consecutively starting below the "contaminated area." If more than three bins are selected, and there are sufficient bins in the column, a mid column beam will be selected. If more than four bins are selected, and there are sufficient bins in the column, the first bin will be selected.

HD – Waves Data Out

Purpose — Select the data output in the Waves Packet Structure.

Format — HD *abc def ghi*

Range — *abc def ghi* can be 1 (On) or 0 (Off).

Default — HD 111 000 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description — This command selects which data will be output in the waves packet data.
a – Velocity
b – Pressure
c – Surface Track
d – Heading, Pitch, and Roll
e-i – Reserved

HF – Waves Flow Control

Purpose — Sets various ADCP waves data flow-control parameters.

Format — HF*nnnnn*

Range — Firmware switches (Res;Res;Res;Ser;Rec) see Table 25, page 102

Default — HF22222

Recommended Setting. The default setting for this command is recommended for most applications.

Description The HF command is similar to the CF command (see "CF - Flow Control," page 38). When the HF command is HF22222 (default), it uses the same settings as the CF command. The HF and CF commands control if the data goes to the recorder and/or to the serial port. This allows you to output Waves data (packets) independently from the standard water current profiles.

Table 25: Waves Flow Control

Command	Description
HFxxx22	Use the same settings as the CF command (default)
HFxxx1x	Enable Serial Output – Sends the currents and waves data ensemble out the RS-232/422 serial interface.
HFxxx0x	Disable Serial Output – No waves ensemble data are sent out the RS-232/422 interface.
HFxxxx1	Enable Data Recorder – Records waves data ensembles on the recorder (if installed).
HFxxxx0	Disable Data Recorder – No waves data ensembles are recorded on the recorder.

NOTE. The default HF22222 will be displayed as HF00000 when a "HF?" command is run.

HP – Waves Pings per Wave Record

Purpose Set the number of pings per wave record.

Format HP*n*

Range *n* = 0 to 8400

Default HP0

Recommended Setting. Set using *WavesPlan*.

Description The command sets the number of pings collected per wave record (or burst). With this value set to zero, Waves data collection is disabled.

HR – Time Between Wave Records

Purpose Set the maximum interval between the start of each wave record.

Format HR *hh*:*mm*:*ss*.*xx*
hh – hours
mm – minutes
ss – seconds
xx – hundredths of seconds

Range 00:00:00.00 – 23:59:59.99

Default HR01:00:00.00

Recommended Setting. Set using *WavesPlan*.

Description This command sets the maximum interval between the start of consecutive wave records. If the number of pings per record * the time between pings is greater than the time between wave records, then the previous wave record will complete before starting the next one.

HS – Bins for Directional Wave Spectrum

Purpose Set the list of bins to use for directional wave spectrum data if the WorkHorse ADCP is not selecting bins automatically.

Format HS n1,n2…n20(Max)

Range n? = 1 - # of Water Profiling Bins (WN).

Default HS1, 10, 21, 22, 23

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command sets the bins to be used for directional wave spectrum processing if automatic bin selection is off. The list can contain a maximum of 20 bins. The limit of each element in the list is set by the number of current profiling bins being collected. This list is completely separate from the Velocity Spectrum bin list, to allow the selection of different bins for Directional Wave and Velocity Spectrum processing.

Example If automatic bin selection is turned off (HB = 0), and the WorkHorse ADCP is collecting 50 bins of current profiling data, the highest single element in the list n1-n20 is limited to 50.

HT – Time Between Wave Record Pings

Purpose Set the maximum interval between each wave ping.

Format HT *hh*:*mm*:*ss*.*xx*
hh – hours
mm – minutes
ss – seconds
xx – hundredths of seconds

Range 00:00:00.00 – 23:59:59.99

Default HT00:00:00.50

Recommended Setting. Set using *WavesPlan*.

Description This command sets the maximum interval between consecutive wave pings. If the number of pings per record * the time between pings is greater than the time between wave records, then the previous wave record will complete before starting the next one.

HV – Bins for Velocity Spectrum

Purpose Set the list of bins to use for velocity spectrum data if the WorkHorse ADCP is not selecting bins automatically.

Format HV n1,n2…n20(Max)

Range n? = 1 - # of Water Profiling Bins (WN).

Default HV1, 10, 21, 22, 23

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command sets the bins to be used for velocity spectrum processing if automatic bin selection is off. The list can contain a maximum of 20 bins. The limit of each element in the list is set by the number of current profiling bins being collected. This list is complete separate from the Directional Wave Spectrum bin list, to allow the selection of different bins for Directional Wave and Velocity Spectrum processing.

Example If automatic bin selection is turned off (HB = 0), and the WorkHorse ADCP is collecting 50 bins of current profiling data, the highest single element in the list n1-n20 is limited to 50.

3.3 Lowered ADCP Commands

The Lowered ADCP (LADCP) uses two WorkHorse ADCPs mounted on a rosette. The rosette is lowered through the water column (one ADCP is looking up and the other is looking down). This setup allows you to cover a larger part of the water column. By lowering the ADCPs through the water column you can get an ocean profile that is greater in range than the two systems combined.

NOTE. Lowered ADCP is a feature upgrade for WorkHorse ADCPs (see "Feature Upgrades," page 5).

Firmware Version 16.28 and lower

NOTE. The Lowered ADCP feature can not co-exist with other feature upgrades using firmware versions prior to 16.30.

Using the L-commands in place of the equivalent W-commands turns on the LADCP feature.

The Lowered ADCP output data format will show up as Water-Profiling Mode 1 and Bottom-Track Mode 11 PD0 data. Bottom-Track Mode 5 will be ignored if the Lowered ADCP feature is used.

Firmware Version 16.30 and above

For firmware version 16.30 and above the Lowered ADCP feature is no longer a totally separate mode that disables the 'W' menu. Using WM15 (see "WM - Profiling Mode," page 94) turns on the LADCP feature and the 'W' commands can be used to set parameters.

NOTE. The 'L' menu has been left in place to minimize changes to customer script files.

The Lowered ADCP output data format will show up as Water-Profiling Mode 15 and Bottom-Track Mode 11 PD0 data. Bottom-Track Mode 5 will be ignored if the Lowered ADCP feature is used.

NOTE. When the user sets WM15, the following commands are set to LADCP-appropriate values:

WB and LW change to 1
LP and WP change to 001
TP changes to 000100
TE changes to 00000100

NOTE. Use the WE command (see "WE - Error Velocity Threshold," page 86) to filter LADCP data based upon error velocity.

3.3.1 Available Lowered ADCP Command

```
>l?
LA = 050 ----------------- False Target Threshold (Max) (0-255 counts)
LC = 064 ----------------- Correlation Threshold
LD = 111 100 000 --------- Data Out (Vel;Cor;Amp  PG;St;P0  P1;P2;P3)
LF = 0044 ---------------- Blank After Transmit (cm)
LJ = 1 ------------------- Rcvr Gain Select (0=Low,1=High)
LN = 030 ----------------- Number of depth cells (1-128)
LP = 00000 --------------- Pings per Ensemble (0-16384)
LS = 0100 ---------------- Depth Cell Size (cm)
LV = 175 ----------------- Ambiguity Velocity (cm/s radial)
LW = 0 ------------------- Band Width Control (0=Wid,1=Nar)
LZ = 030,220 ------------- Amp, Corr Thresholds (0-255)
>
```

3.3.2 Lowered ADCP Command Descriptions

LA – LADCP False Target Threshold Maximum

Purpose — Sets a false target (fish) filter.

Format — LA*nnn*

Range — *nnn* = 0 to 255 counts (255 disables this filter)

Default — LA050

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — The ADCP uses the LA-command to screen water-track data for false targets (usually fish). LA sets the maximum difference between echo intensity readings among the four profiling beams. If the LA threshold value is exceeded, the ADCP rejects velocity data on a cell-by-cell basis for either the affected beam (fish detected in only one beam) or for the affected cell in all four beams (fish detected in more than one beam). This usually occurs when fish pass through one or more beams.

> **NOTE.** A LA command value of 255 turns off this feature.

LC – LADCP Low Correlation Threshold

Purpose — Sets the minimum threshold of water-track data that must meet the correlation criteria.

Format — LC*nnn*

Range — *nnn* = 0 to 255 counts

Default — LC64

Recommended Setting. The default setting for this command is recommended for most applications.

Description — The ADCP uses LC to screen water-track data for the minimum acceptable correlation requirements. The nominal (maximum) correlation depends on system frequency and depth cell size (WS). LC sets the threshold of the correlation below, which the ADCP flags the data as bad and does not average the data into the ensemble.

NOTE. The default threshold for all frequencies is 64 counts. A solid target would have a correlation of 255 counts.

LD – LADCP Data Out

Purpose — Selects the data types collected by the ADCP.

Format — LD *abc def ghi*

Range — Firmware switches (see description)

Default — LD 111 100 000

Recommended Setting. The default setting for this command is recommended for most applications.

Description — LD uses firmware switches to tell the ADCP the types of data to collect. The ADCP always collects header data, fixed/variable leader data, and checksum data. Setting a bit to 1 tells the ADCP to collect that data type. The bits are described as follows:

a = Velocity	*d* = Percent good	*g* = Reserved
b = Correlation	*e* = Status	*h* = Reserved
c = Echo Intensity	*f* = Reserved	*i* = Reserved

Example — LD 111 100 000 (default) tells the ADCP to collect velocity, correlation magnitude, echo intensity, and percent good.

NOTES. Each bit can have a value of one or zero; one means output data, zero means suppress data.

If the LP command is set to LP0 (zero), the ADCP does not collect water-profile data.

Spaces in the command line are allowed.

Status data is not used, as it does not mean anything.

LF – LADCP Blank after Transmit

Purpose — Moves the location of first depth cell away from the transducer head to allow the transmit circuits time to recover before the receive cycle begins.

Format — LF*nnnn*

Range — *nnnn* = 0 to 9999 cm

Default — LF0704 (75 kHz), LF0176 (300 kHz), LF0088 (600 kHz), LF0044 (1200 kHz), LF0022 (2400 kHz)

Recommended Setting. The default setting for this command is recommended for most applications.

Description — LF positions the start of the first depth cell at some vertical distance from the transducer head. This allows the ADCP transmit circuits time to recover before beginning the receive cycle. In effect, LF blanks out bad data close to the transducer head, thus creating a depth window that reduces unwanted data in the ensemble.

NOTES.

1. The distance to the middle of depth cell #1 is a function of blank after transmit (LF), depth cell size (LS), and speed of sound. The fixed leader data contains this distance.
2. Small LF values may show ringing/recovery problems in the first depth cells that cannot be screened by the ADCP.

LJ - Receiver Gain Select

Purpose — Allows the ADCP to reduce receiver gain by 40 dB.

Format — LJn

Range — n = 0 (low), 1 (high)

Default — LJ1

Recommended Setting. The default setting for this command is recommended for most applications.

Description — LJ0 tells the ADCP to reduce receiver gain by 40 dB. This may increase data reliability in shallow-water applications where there is a high content of backscatter material. LJ1 (the default) uses the normal receiver gain.

LN – Number of Depth Cells

Purpose — Sets the number of depth cells over which the ADCP collects data.

Format — LN*nnn*

Range — *nnn* = 001 to 128 depth cells

Default — LN030

Recommended Setting. Set using *WinSC*.

Description — The range of the ADCP is set by the number of depth cells (LN) times the size of each depth cell (LS).

LP – Pings Per Ensemble

Purpose — Sets the number of pings to average in each data ensemble.

Format — LP*nnnnn*

Range — *nnnnn* = 0 to 16384 pings

Default — LP00001

Recommended Setting. Set using *WinSC*.

Description — LP sets the number of pings to average in each ensemble before sending/recording the data.

NOTES.

1. If LP = zero the ADCP does not collect water-profile data.
2. The ADCP automatically extends the ensemble interval (TE) if LP x TP > TE.

LS – Depth Cell Size

Purpose — Selects the volume of water for one measurement cell.

Format — LS*nnnn*

Range — *nnnn* = See Table below.

Default — See Table 26, page 110.

Recommended Setting. Set using *WinSC*.

Table 26: Lowered ADCP Depth Cell Size

	300kHz	600kHz	1200kHz	2400kHz
Range	20 to 1600 cm	10 to 800 cm	5 to 400 cm	5 to 200 cm
Default	LS0400	LS0200	LS0100	LS0050

Description The ADCP collects data over a variable number of depth cells. LS sets the size of each cell in vertical centimeters.

NOTE. If you set LS to a value less than its minimum value or greater than its maximum value, the ADCP will accept the entry, but uses the appropriate minimum or maximum value. For example, if you enter LS1 for a 300kHz system, the ADCP uses a value of 20 cm for LS. Similarly, if you enter LS5000 for a 600kHz system, the ADCP uses a value of 800 cm for the LS command.

LV – Ambiguity Velocity

Purpose Sets the radial ambiguity velocity.

Format LV*nnn*

Range *nnn* = 002 to 700 cm/s

Default LV175

Recommended Setting. The default setting for this command is recommended for most applications.

Description Set LV as low as possible to attain maximum performance, but not too low or ambiguity errors will occur. Rule of thumb: Set LV to the maximum relative horizontal velocity between water-current speed and ADCP speed.

Example If the maximum expected ADCP velocity (vessel velocity) is 250 cm/s (»5 kt) and the maximum expected horizontal water velocity is 100 cm/s, set LV to 350 cm/s.

NOTE. Note that the minimum setting of the LV command is LV002 and the maximum setting due to internal processing limitations is limited based on the setting of the bandwidth command, LW.

LV is limited to 330 cm/s in Narrow bandwidth mode (LW1), which increases the profiling range by 10% compared to Broad bandwidth mode (LW0).

When the LW command is set to LW0, the max value is LV700.

In either case, while you can set a value as low as 2 cm/s, this will likely cause ambiguity errors. TRDI recommends setting LV to ≥ 100cm/s for most applications.

LW - Bandwidth Control

Purpose — The LW commands sets the profiling bandwidth (sampling rate). Smaller bandwidths allow the ADCP to profile farther, but the standard deviation is increased by as much as 2.5 times.

Format — LW*n*

Range — *n* = 0 (Wide), 1 (Narrow)

Default — LW1

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — See Table 27.

Table 27: Bandwidth Control

Bandwidth	Sample rate	Data variance	Profiling range
0 = Wide (25%)	High	Low	Low
1 = Narrow (6.25%)	Low	High	High

LZ – LADCP Amplitude and Correlation Thresholds

Purpose — Sets the minimum correlation magnitude and threshold for good bottom-track data.

Format — LZ*aaa*,*ccc*

Range — *aaa* = bottom detection threshold (0 to 255 counts)

ccc = correlation magnitude (1 to 255 counts)

Default — LZ030,220

> **Recommended Setting.** The default setting for this command is recommended for most applications.

Description — LZ sets the minimum amplitude of an internal bottom-track filter that determines bottom detection. Reducing LZ increases the bottom-track detection range, but also may increase the possibility of false bottom detections.

The LZ command also sets the minimum threshold for good bottom-track data. The ADCP flags as bad any bottom-track data with a correlation magnitude less than this value. A count value of 255 is a perfect correlation (i.e. solid target).

3.4 Ping Synchronization Commands

The Teledyne RD Instruments Sleepy Sensor Synchronization (TRDS[3]) protocol allows a WorkHorse ADCP to synchronize measurements with another ADCP or any other instrument that adheres to the RDS[3] specification.

3.4.1 Available Ping Synchronization Commands

```
>s?
SA = 001 ----------------- Synch Before/After Ping/Ensemble Bottom/Water/Both
SB = 1 ------------------- Channel B Break Interrupts are Enabled
SI = 00000 --------------- Synch Interval (0-65535)
SM = 0 ------------------- Mode Select (0=OFF,1=MASTER,2=SLAVE,3=NEMO)
SS = 0 ------------------- RDS3 Sleep Mode (0=No Sleep)
ST = 00000 --------------- Slave Timeout (seconds,0=indefinite)
SW = 00000 --------------- Synch Delay (1/10 msec)
>
```

NOTE. To see the S commands as listed above, the Experton command must be used (see “Expert Mode,” page 15).

3.4.2 Ping Synchronization Command Descriptions

SA - Synchronize Before/After Ping/Ensemble

Purpose — Sets the rough timing of the synchronization pulse.

Format — SA*xyz*

Range — *x* = 0, 1
y = 0, 1
z = 0, 1, 2

Default — SA001

Recommended Setting. Special applications only.

Description — Use the SA command to set the rough timing of the synchronization pulse. The first parameter determines whether the Master (or Slave) will send (or wait for) a synchronization pulse before or after the conditions set in parameters y and z. If the second parameter is set to Ping, the third parameter determines what kind of ping to synchronize on. If parameter y is set to Ensemble, the third parameter is ignored (but must still be entered).

Table 28: Synchronization Parameters

Parameter	Description
SA000	Send (wait for) pulse before a bottom ping.
SA001	Send (wait for) pulse before a water ping.
SA002	Send (wait for) pulse before both pings
SA100	Send (wait for) pulse after a bottom ping.
SA101	Send (wait for) pulse after a water ping.
SA102	Send (wait for) pulse after both pings.
SA01X	Send (wait for) pulse before ensemble.
SA11X	Send (wait for) pulse after ensemble.

NOTE. This command has no effect unless SM = 1 or 2.

SB –Channel B Break Interrupt Mode

Purpose — Disables the hardware-break detection on the ping synchronization input port, Channel B.

Format — SB*x*

Range — *x* = 0 (disable hardware-break detection on Channel B)
x = 1 (enable hardware-break detection on Channel B)

Default — SB1

Description — To avoid a ping synchronization input from being handled as a hardware-break, disable hardware-break detection on the ping synchronization input port, Channel B, by setting SB to 0.

CAUTION. Use SB0 only when the ADCP does not conserve power (i.e. go to sleep) between samples (see “CL - Battery Saver Mode,” page 41 and “SS - RDS3 Sleep Mode,” page 115).

CAUTION. When changing the SB command, confirm the change by immediately following the SB change with a BREAK (see “Break,” page 14).

NOTE. The SB command is not affected by the CR command (see “CR – Retrieve Parameters,” page 43)

This command is available in firmware versions 16.30 and higher.

SI - Synchronization Interval

Purpose	Sets how many pings/ensembles to wait before sending the next synchronization pulse.
Format	SI*nnnnn*
Range	*nnnnn* = 0 to 65535
Default	SI0

Recommended Setting. Special applications only.

Description Use the SI command to set how many pings/ensembles (depending on the SA command) to wait before sending the next synchronization pulse.

NOTE. This command has no effect unless SM = 1

SM - RDS3 Mode Select

Purpose	Sets the RDS3 Mode.
Format	SM*n*
Range	*n* = 0 (Off), 1 (RDS3 Master), 2 (RDS3 Slave), 3 (NEMO)
Default	SM0

Recommended Setting. Special applications only.

Description SM sets the RDS3 Mode. SM0 turns off the RDS3 mode and disables all other commands on this menu. SM1 sets the RDS3 Master mode and enables the SA, SI, SS, and SW commands. SM2 sets the RDS3 Slave mode and enables the SA, SS, and ST commands. SM3 sets the NEMO Mode and enables the SW command.

NOTE. When the SM command is used, the communication switch on the ADCP's PIO board must be in the RS232 position.

SS - RDS3 Sleep Mode

Purpose Sets the RDS3 Sleep Mode.

Format SS*x*

Range *x* = 0, 1 (0 = No Sleep, 1 = Sleep)

Default SS0

Recommended Setting. The default setting for this command is recommended for most applications.

Description This command sets the RDS3 Sleep Mode. When x is set to No Sleep, the instrument remains awake while waiting for the next ping time (or synchronization pulse) in a loop. When x is set to Sleep, the instrument sleeps between pings (or synchronization pulses.) There are limitations to using the Sleep Mode. A TRDI WorkHorse ADCP, setup as a slave, can only synchronize to within 2.5 ms of the Master. When the Slave is in No Sleep Mode, the slave can ping to within 500 microseconds of the master. The benefits of power saving cost are synchronization accuracy.

Table 29: Sleep Mode Parameters

Parameter	Description
SS0	Wait between pings (synchronization pulses) in a loop.
SS1	Wait between pings (synchronization pulses) in a sleep state.

NOTE. This command has no effect unless SM = 1 or 2

ST - Slave Timeout

Purpose Sets the amount of time a slave will wait to hear a synch pulse before proceeding on its own.

Format ST*n*

Range *n* = 0 to 10800 seconds

Default ST0

Recommended Setting. Special applications only.

Description ST sets the amount of time a slave will wait to hear a synch pulse before proceeding on its own. If a slave times out, it will automatically ping according to the CF, TP, TE, WP, and BP command settings. This is a fail-safe mechanism designed

to allow the slave to proceed on its own should communications with the master ADCP fail. Setting ST = 0 tells the slave to wait indefinitely.

NOTE. This command has no effect unless SM = 2

SW - Synchronization Delay

Purpose	Sets the amount of time to wait after sending the pulse.
Format	SW*n*
Range	*n* = 0 to 65535 (units of 0.1 milliseconds)
Default	SW00075

Recommended Setting. The default setting for this command is recommended for most applications.

Description Use the SW command to set the amount of time to wait after sending the pulse before proceeding. For example, setting the SW command to SW20000 will add a delay of 2 seconds. This allows precise timing of measurements.

When a Master attempts to ping a slave ADCP, it sends out a pulse to the slave ADCP. The slave ADCP has a different code path than the Master ADCP and thus, they will take different amounts of time to start the ping. By adding in the default Master Delay of 7.5 ms, the code paths are evened up to allow the units to start the pings at about the same time (typically within 100 microseconds of each other).

NOTE. This command has no effect unless SM = 1 or 3

3.4.3 Example Master/Slave Setup

Master Slave Initialization

a. Connect the master and slave ADCPs to two PC comports via a master/slave cable.

b. Apply power to the ADCPs.

c. Establish RS-232 communications between *BBTalk* and the master and slave ADCPs.

d. Set both the master and slave ADCP to the same baud rate (see Note 1).

e. Send a BREAK to the master ADCP.

f. Verify that the master ADCP outputs the RS-232 banner (see Note 2).

g. Send a CR1 and CK command to the master ADCP.

h. Send a BREAK to the slave ADCP.

i. Verify that the slave ADCP outputs the RS-232 banner.

j. Send a CR1 and CK to the slave ADCP.

k. Send the configuration commands to the master ADCP, omitting the CS command to start sampling.

l. Send the configuration commands to the slave ADCP including the CS command to start sampling.

m. Now send the CS commands to the master ADCP.

The master samples, and triggers the slave, which samples. This continues until the power is not available, or the user or some other force intervenes.

Terminating data collection

a. Send a BREAK to the master ADCP (see note 2).

b. Verify that the master ADCP outputs the RS-232 banner (see note 2).

c. Send a CZ command to the master ADCP.

d. Send a BREAK to the slave ADCP.

e. Verify that the slave ADCP outputs the RS-232 banner (see note 2).

f. Send the CZ command to the slave ADCP.

NOTE 1.

The master and slave ADCP must use the same baud rate. Baud rate options depend on whether the master and slave ADCP are allowed to go to low power mode between samples. When the master and slave cannot go to low power mode between samples, the user can select all baud rates less than 115200 (i.e. one can use 1200, 2400, 4800, 9600, 19200, 38400, or 57600 baud).

When the master and slave ADCP can go to low power mode between samples, the user can select 1200, 2400, 4800, or 9600 baud.

NOTE 2.

The master slave cable connects the units via an RS-485 bus so the master ADCP can trigger the slave ADCP to sample. The RS-485 bus can alternately be used for RS-422 communications. However, during initialization, when the master ADCP receives a BREAK and outputs the wakeup banner, it also may cause the slave ADCP to output an incomplete banner. When this occurs, send additional BREAKs to the master ADCP until the slave ADCP outputs a full RS-422 banner.

Example Wakeup Banners

RS232 Banner

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.30
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>
```

RS422 Banner

```
[BREAK Wakeup B]
WorkHorse Broadband ADCP Version 16.30
Teledyne RD Instruments (c) 1996-2007
All Rights Reserved.
>
```

Incomplete Banner

```
[BR
```

4 Introduction to Output Data Format

This section shows the output data format of the WorkHorse ADCP (including the Monitor/Sentinel, Quartermaster, and Long Ranger). WorkHorse ADCP output data can be in either hexadecimal-ASCII or binary format. You can select this option through the CF-command (see the "CF - Flow Control," page 38). We explain the output data formats in enough detail to let you create your own data processing or analysis programs (see "How to Decode an ADCP Ensemble," page 176).

4.1 Hexadecimal-ASCII Output Data

Use the hexadecimal-ASCII (Hex ASCII) format (CFxx0xx) when you are viewing raw WorkHorse ADCP data on a computer/dumb terminal. This format uses the standard ASCII codes for 0 through F to represent numeric values as hexadecimal digits. Other standard ASCII characters (text) and control commands (carriage return, line feed, end of file, etc.) are interpreted normally. In the Hex ASCII mode, the ADCP sends data in one line of ASCII characters. There are no carriage returns and/or line feed sequences (CR/LF) sent from the ADCP. The CRT provides a CR/LF after 60 characters.

NOTE. Hex ASCII PD0 data is not supported by TRDI's software.

4.2 Binary Output Data Format

Use the binary format (CFxx1xx) when recording/processing WorkHorse ADCP data on an external device. The binary format uses less storage space and has a faster transmission time than the Hex ASCII format. A dumb terminal is of little use in binary format because the terminal interprets some of the data as control characters.

NOTE. All of TRDI's software supports binary PD0 formatted data only.

4.3 What Data Format Should I Use and Why?

The WorkHorse ADCP can output data in several user selectable formats using the PD command (see "PD - Data Stream Select," page 59). Depending on the output format selected, data will be either binary or ASCII text. Individual parameters within a data string may be enabled / disabled. All binary output formats have the option of outputting data in HEX-ASCII instead of true binary using the CF command (see "CF - Flow Control," page 38). HEX-ASCII is an ASCII representation of the binary data. Binary output formats include PD0, 3, 4, 5 and 10. Text output formats include PD6, 8, and 9.

Deciding on which format to use depends on the needs of the deployment. The following describes the basics of the formats available.

- **PD0** – PD0 is Teledyne RD Instrument's standard format. PD0 is a binary output format. It provides the most information possible including a header, fixed and variable leader, bottom track, and water profile information. The fixed and variable leader is a recording of time, ADCP setup, orientation, heading, pitch, roll, temperature, pressure, and self test diagnostic results. Data fields to be output are user selectable.
- **PD3** – PD3 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information.
- **PD4** – PD4 is a binary output format of bottom track speed over the bottom, speed through the water, and range to bottom information.
- **PD5** – PD5 is a superset of PD4 and includes information on salinity, depth, pitch, roll, heading, and distance made good.
- **PD6** – PD6 is a text output format. Data is grouped into separate sentences containing system attitude data, timing and scaling, and speed through the water relative to the instrument, vehicle, and earth. Each sentence contains a unique starting delimiter and comma delimited fields.
- **PD8** – PD8 outputs ensemble data as formatted text. A new-line character terminates each line. Two new-line characters terminate an ensemble. PD8 data is only for serial output; the ADCP will output PD8 ASCII data out the serial port and record PD0 data to the recorder card (if enabled).
- **PD9** – PD9 is a water-profiling format meant to collect data in earth coordinates and formatted for easy parsing. All fields are fixed width, comma separated, and either zero or space padded.
- **PD10** – PD10 is similar to PD3 but with the addition of pressure and depth fields.

Special Application Output Formats

- **PD12 –** is suitable for use in applications where communications bandwidth is an issue, such as acoustic modems and radio modems.
- **PD15 –** is for use with NDBC satellite data links.
- **PD16** and **PD18** – are for use with Sea-Bird acoustic modems.

The following table is a summary of the type of data outputted by PD0 through PD10 data output formats. Note that this is not an exhaustive list and it is advised to check out the full description of a format before choosing it above another.

Table 30: Summary of Output Data Formats

	PD0	PD3	PD4	PD5	PD6	PD8	PD9	PD10
System Info	☑		☑	☑				
Temperature	☑	☑	☑	☑	☑	☑	☑	☑
Depth	☑			☑	☑			☑
Tilts (H,P,R)	☑	☑		☑	☑	☑	☑	☑
Time of Ping	☑	☑	☑	☑	☑	☑	☑	☑
Speed of Sound	☑		☑	☑	☑	☑		
Water Profile Configuration	☑							
Water Profile Velocities	☑					☑	☑	
Correlation Magnitude	☑					☑		
Echo Intensity	☑					☑		
Percent Good	☑							
Bottom Range	☑	☑	☑	☑	☑			☑
Bottom Velocity (SOG*)	☑	☑	☑	☑	☑			☑
Water-Mass Layer Velocity (STW*)	☑	☑	☑	☑	☑			☑
Bottom Track Configuration	☑							
Distance Over Ground				☑				
Binary	☑	☑	☑	☑	☑	☑		☑
ASCII					☑		☑	
Serial Output						☑		

*SOG = Speed Over Ground
*STW = Speed Through Water

5 PD0 Output Data Format

The following description is for the standard PD0 WorkHorse ADCP output data format. Figure 10, page 124 through Figure 17, page 150 shows the ASCII and binary data formats for the WorkHorse ADCP PD0 mode. Table 31, page 125 through Table 40, page 150 defines each field in the output data structure.

After completing a data collection cycle, the WorkHorse ADCP immediately sends a data ensemble. The following pages show the types and sequence of data that you may include in the WorkHorse ADCP output data ensemble and the number of bytes required for each data type. The WorkHorse ADCP sends all the data for a given type for all depth cells and all beams before the next data type begins.

The WorkHorse ADCP by default is set to collect velocity, correlation data, echo intensity, and percent good data. The data, preceded by ID code 7F7F, contains header data (explained in Table 31, page 125). The fixed and variable leader data is preceded by ID codes 0000 and 8000, (explained in Table 32, page 128 and Table 33, page 134). The WorkHorse ADCP always collects Header and Leader.

The remaining lines include velocity (ID Code: 0001), correlation magnitude (0002), echo intensity (0003), and percent good (0004). The final field is a data-validity checksum.

ALWAYS OUTPUT	**HEADER** (6 BYTES + [2 x No. OF DATA TYPES])
	FIXED LEADER DATA (59 BYTES)
	VARIABLE LEADER DATA (65 BYTES)
WD-command WP-command	**VELOCITY** (2 BYTES + 8 BYTES PER DEPTH CELL)
	CORRELATION MAGNITUDE (2 BYTES + 4 BYTES PER DEPTH CELL)
	ECHO INTENSITY (2 BYTES + 4 BYTES PER DEPTH CELL)
	PERCENT GOOD (2 BYTES + 4 BYTES PER DEPTH CELL)
BP-command	**BOTTOM TRACK DATA** (85 BYTES)
ALWAYS OUTPUT	**RESERVED** (2 BYTES)
	CHECKSUM (2 BYTES)

Figure 9. PD0 Standard Output Data Buffer Format

Some data outputs are in bytes per depth cell. For example, if the WN- command (number of depth cells) = 30 (default), WD command = WD 111 100 000 (default), WP command > 0, BP command > 0, the required data buffer storage space is 841 bytes per ensemble.

There are seven data types output for this example: Fixed Leader, Variable Leader, Velocity, Correlation Magnitude, Echo Intensity, Percent Good, and Bottom Track.

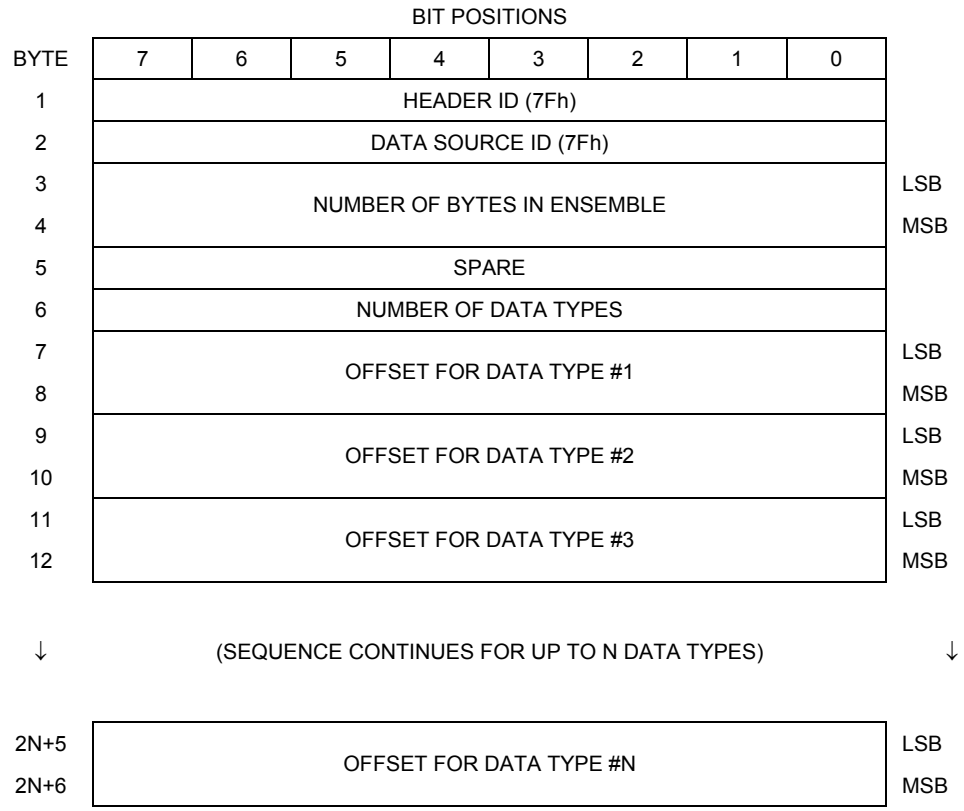
```
  20  BYTES OF HEADER DATA (6 + [2 x 7 Data Types])
  59  BYTES OF FIXED LEADER DATA (FIXED)
  65  BYTES OF VARIABLE LEADER DATA (FIXED)
 242  BYTES OF VELOCITY DATA (2 + 8 x 30)
 122  BYTES OF CORRELATION MAGNITUDE DATA (2 + 4 x 30)
 122  BYTES OF ECHO INTENSITY (2 + 4 x 30)
 122  BYTES OF PERCENT-GOOD DATA (2 + 4 x 30)
  85  BYTES OF BOTTOM TRACK DATA (FIXED)
   2  BYTES OF RESERVED FOR TRDI USE (FIXED)
   2  BYTES OF CHECKSUM DATA (FIXED)
-----
 841  BYTES OF DATA PER ENSEMBLE
```

NOTE. *WinRiver* and *VmDas* may add additional bytes.

For example, WinRiver does not add any bytes to the Bottom Track data, but does insert data in place of other bytes. The Navigation NMEA strings (up to 275 bytes) are stored in the *r.000 raw data between the Bottom Track data and the Reserved/Checksum data. WinRiver output data format is described in the WinRiver User's Guide.

VmDas adds 78 bytes of Navigation data between the Bottom Track data and the Reserved/Checksum data. The ENR file (raw data from the ADCP) does not have these bytes, only the ENS, ENX, STA and LTA files. VmDas output data format is described in the VmDas User's Guide.

5.1 Header Data Format



See Table 31, page 125 for a description of the fields.

Figure 10. Header Data Format

Header information is the first item sent by the ADCP to the output buffer. The WorkHorse ADCP always sends the Least Significant Byte (LSB) first.

Table 31: Header Data Format

Hex Digit	Binary Byte	Field	Description
1,2	1	HDR ID / Header ID	Stores the header identification byte (7Fh).
3,4	2	HDR ID / Data Source ID	Stores the data source identification byte (7Fh for the WorkHorse ADCP).
5-8	3,4	Bytes / Number of bytes in ensemble	This field contains the number of bytes from the start of the current ensemble up to, but not including, the 2-byte checksum (Figure 17, page 150).
9,10	5	Spare	Undefined.
11,12	6	No. DT / Number of Data Types	This field contains the number of data types selected for collection. By default, fixed/variable leader, velocity, correlation magnitude, echo intensity, and percent good are selected for collection. This field will therefore have a value of six (4 data types + 2 for the Fixed/Variable Leader data).
13-16	7,8	Address Offset for Data Type #1 / Offset for Data Type #1	This field contains the internal memory address offset where the WorkHorse ADCP will store information for data type #1 (with this firmware, always the Fixed Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #1 begins (the first byte of the ensemble is Binary Byte #1).
17-20	9,10	Address Offset for Data Type #2 / Offset for Data Type #2	This field contains the internal memory address offset where the WorkHorse ADCP will store information for data type #2 (with this firmware, always the Variable Leader). Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Type #2 begins (the first byte of the ensemble is Binary Byte #1).
21-24 thru 2n+13 to 2n+16	11,12 thru 2n+5, 2n+6	Address Offsets for Data Types #3-n / Offset for Data Type #3 through #n	These fields contain internal memory address offset where the WorkHorse ADCP will store information for data type #3 through data type #n. Adding “1” to this offset number gives the absolute Binary Byte number in the ensemble where Data Types #3-n begin (first byte of ensemble is Binary Byte) #1).

5.2 Fixed Leader Data Format

BYTE	BIT POSITIONS 7	6	5	4	3	2	1	0	
1	FIXED LEADER ID								LSB 00h
2									MSB 00h
3	CPU F/W VER.								
4	CPU F/W REV.								
5	SYSTEM CONFIGURATION								LSB
6									MSB
7	REAL/SIM FLAG								
8	LAG LENGTH								
9	NUMBER OF BEAMS								
10	NUMBER OF CELLS {WN}								
11	PINGS PER ENSEMBLE {WP}								LSB
12									MSB
13	DEPTH CELL LENGTH {WS}								LSB
14									MSB
15	BLANK AFTER TRANSMIT {WF}								LSB
16									MSB
17	PROFILING MODE {WM}								
18	LOW CORR THRESH {WC}								
19	NO. CODE REPS								
20	%GD MINIMUM {WG}								
21	ERROR VELOCITY MAXIMUM {WE}								LSB
22									MSB
23	TPP MINUTES								
24	TPP SECONDS								
25	TPP HUNDREDTHS {TP}								
26	COORDINATE TRANSFORM {EX}								
27	HEADING ALIGNMENT {EA}								LSB
28									MSB

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Continued from Previous Page

29	HEADING BIAS {EB}	LSB
30		MSB
31	SENSOR SOURCE {EZ}	
32	SENSORS AVAILABLE	
33	BIN 1 DISTANCE	
34		
35	XMIT PULSE LENGTH BASED ON {WT}	LSB
36		MSB
37	(starting cell) WP REF LAYER AVERAGE {WL} (ending cell)	LSB
38		MSB
39	FALSE TARGET THRESH {WA}	
40	SPARE	
41	TRANSMIT LAG DISTANCE	LSB
42		MSB
43	CPU BOARD SERIAL NUMBER	LSB
↓		↓
50		MSB
51	SYSTEM BANDWIDTH {WB}	LSB
52		MSB
53	SYSTEM POWER {CQ}	
54	SPARE	
55	INSTRUMENT SERIAL NUMBER	
↓		
58		
59	BEAM ANGLE	

See Table 32, page 128 for a description of the fields

Figure 11. Fixed Leader Data Format

Fixed Leader data refers to the non-dynamic WorkHorse ADCP data that only changes when you change certain commands. Fixed Leader data also contain hardware information. The WorkHorse ADCP always sends Fixed Leader data as output data (LSBs first).

Table 32: Fixed Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	FID / Fixed Leader ID	Stores the Fixed Leader identification word (00 00h).
5,6	3	fv / CPU F/W Ver.	Contains the version number of the CPU firmware.
7,8	4	fr / CPU F/W Rev.	Contains the revision number of the CPU firmware.
9-12	5,6	Sys Cfg / System Configuration	This field defines the WorkHorse ADCP hardware configuration. Convert this field (2 bytes, LSB first) to binary and interpret as follows. LSB BITS 7 6 5 4 3 2 1 0 - - - - - 0 0 0 75-kHz SYSTEM - - - - - 0 0 1 150-kHz SYSTEM - - - - - 0 1 0 300-kHz SYSTEM - - - - - 0 1 1 600-kHz SYSTEM - - - - - 1 0 0 1200-kHz SYSTEM - - - - - 1 0 1 2400-kHz SYSTEM - - - - 0 - - - CONCAVE BEAM PAT. - - - - 1 - - - CONVEX BEAM PAT. - - 0 0 - - - - SENSOR CONFIG #1 - - 0 1 - - - - SENSOR CONFIG #2 - - 1 0 - - - - SENSOR CONFIG #3 - 0 - - - - - - XDCR HD NOT ATT. - 1 - - - - - - XDCR HD ATTACHED 0 - - - - - - - DOWN FACING BEAM 1 - - - - - - - UP-FACING BEAM MSB BITS 7 6 5 4 3 2 1 0 - - - - - - 0 0 15E BEAM ANGLE - - - - - - 0 1 20E BEAM ANGLE - - - - - - 1 0 30E BEAM ANGLE - - - - - - 1 1 OTHER BEAM ANGLE 0 1 0 0 - - - - 4-BEAM JANUS CONFIG 0 1 0 1 - - - - 5-BM JANUS CFIG DEMOD) 1 1 1 1 - - - - 5-BM JANUS CFIG.(2 DEMD) Example: Hex 5249 (i.e., hex 49 followed by hex 52) identifies a 150-kHz system, convex beam pattern, down-facing, 30E beam angle, 5 beams (3 demods).
13,14	7	PD / Real/Sim Flag	This field is set by default as real data (0).

Continued next page

Table 32: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
15,16	8	Lag Length	Lag Length. The lag is the time period between sound pulses. This is varied, and therefore of interest in, at a minimum, for the WM5, WM8 and WM11 and BM7 commands.
17,18	9	#Bm / Number of Beams	Contains the number of beams used to calculate velocity data (not physical beams). The WorkHorse ADCP needs only three beams to calculate water-current velocities. The fourth beam provides an error velocity that determines data validity. If only three beams are available, the WorkHorse ADCP does not make this validity check. Table 37, page 144 (Percent-Good Data Format) has more information.
19,20	10	WN / Number of Cells	Contains the number of depth cells over which the WorkHorse ADCP collects data (WN-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
21-24	11,12	WP / Pings Per Ensemble	Contains the number of pings averaged together during a data ensemble (WP-command). If WP = 0, the WorkHorse ADCP does not collect the WD water-profile data. Note: The Work-Horse ADCP automatically extends the ensemble interval (TE) if the product of WP and time per ping (TP) is greater than TE (i.e., if WP x TP > TE). Scaling: LSD = 1 ping; Range = 0 to 16,384 pings
25-28	13,14	WS / Depth Cell Length	Contains the length of one depth cell (WS-command). Scaling: LSD = 1 centimeter; Range = 1 to 6400 cm (210 feet)
29-32	15,16	WF / Blank after Transmit	Contains the blanking distance used by the WorkHorse ADCP to allow the transmit circuits time to recover before the receive cycle begins (WF-command). Scaling: LSD = 1 centimeter; Range = 0 to 9999 cm (328 feet)
33,34	17	Signal Proc-essing Mode	Contains the Signal Processing Mode. This field will always be set to 1.
35,36	18	WC / Low Corr Thresh	Contains the minimum threshold of correlation that water-profile data can have to be considered good data (WC-command). Scaling: LSD = 1 count; Range = 0 to 255 counts
37,38	19	cr# / No. code reps	Contains the number of code repetitions in the transmit pulse. Scaling: LSD = 1 count; Range = 0 to 255 counts
39,40	20	WG / %Gd Minimum	Contains the minimum percentage of water-profiling pings in an ensemble that must be considered good to output velocity data. Scaling: LSD = 1 percent; Range = 1 to 100 percent
41-44	21,22	WE / Error Velocity Threshold	This field, initially set by the WE-command, contains the actual threshold value used to flag water-current data as good or bad. If the error velocity value exceeds this threshold, the Work-Horse ADCP flags all four beams of the affected bin as bad. Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s
45,46	23	Minutes	These fields, set by the TP-command, contain the amount of time between ping groups in the ensemble. NOTE: The WorkHorse ADCP automatically extends the ensemble interval (set by TE) if (WP x TP > TE).
47,48	24	Seconds	
49,50	25	Hundredths	

Table 32: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
51,52	26	EX / Coord Transform	Contains the coordinate transformation processing parameters (EX-command). These firmware switches indicate how the WorkHorse ADCP collected data. xxx00xxx = NO TRANSFORMATION (BEAM COORDINATES) xxx01xxx = INSTRUMENT COORDINATES xxx10xxx = SHIP COORDINATES xxx11xxx = EARTH COORDINATES xxxxx1xx = TILTS (PITCH AND ROLL) USED IN SHIP OR EARTH TRANSFORMATION xxxxxx1x = 3-BEAM SOLUTION USED IF ONE BEAM IS BELOW THE CORRELATION THRESHOLD SET BY THE WC-COMMAND xxxxxxx1 = BIN MAPPING USED
53-56	27,28	EA / Heading Alignment	Contains a correction factor for physical heading misalignment (EA-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
57-60	29,30	EB / Heading Bias	Contains a correction factor for electrical/magnetic heading bias (EB-command). Scaling: LSD = 0.01 degree; Range = -179.99 to 180.00 degrees
61,62	31	EZ / Sensor Source	Contains the selected source of environmental sensor data (EZ-command). These firmware switches indicate the following. FIELD DESCRIPTION x1xxxxxx = CALCULATES EC (SPEED OF SOUND) FROM ED, ES, AND ET xx1xxxxx = USES ED FROM DEPTH SENSOR xxx1xxxx = USES EH FROM TRANSDUCER HEADING SENSOR xxxx1xxx = USES EP FROM TRANSDUCER PITCH SENSOR xxxxx1xx = USES ER FROM TRANSDUCER ROLL SENSOR xxxxxx1x = USES ES (SALINITY) FROM CONDUCTIVITY SENSOR xxxxxxx1 = USES ET FROM TRANSDUCER TEMPERATURE SENSOR NOTE: If the field = 0, or if the sensor is not available, the WorkHorse ADCP uses the manual command setting. If the field = 1, the WorkHorse ADCP uses the reading from the internal sensor or an external synchro sensor (only applicable to heading, roll, and pitch). Although you can enter a “2” in the EZ-command string, the WorkHorse ADCP only displays a 0 (manual) or 1 (int/ext sensor).
63,64	32	Sensor Avail	This field reflects which sensors are available. The bit pattern is the same as listed for the EZ-command (above).
65-68	33,34	dis1 / Bin 1 distance	This field contains the distance to the middle of the first depth cell (bin). This distance is a function of depth cell length (WS), the profiling mode (WM), the blank after transmit distance (WF), and speed of sound. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)

Table 32: Fixed Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
69-72	35,36	WT Xmit pulse length	This field, set by the WT-command, contains the length of the transmit pulse. When the WorkHorse ADCP receives a <BREAK> signal, it sets the transmit pulse length as close as possible to the depth cell length (WS-command). This means the WorkHorse ADCP uses a WT command of zero. However, the WT field contains the actual length of the transmit pulse used. Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm (2150 feet)
73,74 75,76	37,38	WL / WP Ref Lyr Avg (Starting cell, Ending cell)	Contains the starting depth cell (LSB, byte 37) and the ending depth cell (MSB, byte 38) used for water reference layer averaging (WL-command). Scaling: LSD = 1 depth cell; Range = 1 to 128 depth cells
77,78	39	WA / False Target Threshold	Contains the threshold value used to reject data received from a false target, usually fish (WA-command). Scaling: LSD = 1 count; Range = 0 to 255 counts (255 disables)
79,80	40	Spare	Contains the CX-command setting. Range = 0 to 5
81-84	41,42	LagD / Transmit lag distance	This field, determined mainly by the setting of the WM-command, contains the distance between pulse repetitions. Scaling: LSD = 1 centimeter; Range = 0 to 65535 centimeters
85-100	43-50	CPU Board Serial Number	Contains the serial number of the CPU board.
101-105	51-52	WB / System Bandwidth	Contains the WB-command setting. Range = 0 to 1
106-107	53	System Power	Contains the CQ-command setting for WorkHorse ADCP Monitor/Sentinel/Long Ranger ADCPs. Range 0 to 255.
108-109	54	Spare	Spare
110-119	55-58	Serial #	Instrument serial number
120 -121	59	Beam Angle	Beam angle

5.3 Variable Leader Data Format

	BIT POSITIONS								
BYTE	7	6	5	4	3	2	1	0	
1	VARIABLE LEADER ID								80h
2									00h
3	ENSEMBLE NUMBER								LSB
4									MSB
5	RTC YEAR {TS}								
6	RTC MONTH {TS}								
7	RTC DAY {TS}								
8	RTC HOUR {TS}								
9	RTC MINUTE {TS}								
10	RTC SECOND {TS}								
11	RTC HUNDREDTHS {TS}								
12	ENSEMBLE # MSB								
13	BIT RESULT								LSB
14									MSB
15	SPEED OF SOUND {EC}								LSB
16									MSB
17	DEPTH OF TRANSDUCER {ED}								LSB
18									MSB
19	HEADING {EH}								LSB
20									MSB
21	PITCH (TILT 1) {EP}								LSB
22									MSB
23	ROLL (TILT 2) {ER}								LSB
24									MSB
25	SALINITY {ES}								LSB
26									MSB
27	TEMPERATURE {ET}								LSB
28									MSB
29	MPT MINUTES								
30	MPT SECONDS								
31	MPT HUNDREDTHS								
32	HDG STD DEV								
33	PITCH STD DEV								
34	ROLL STD DEV								

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35	ADC CHANNEL 0	
36	ADC CHANNEL 1	
37	ADC CHANNEL 2	
38	ADC CHANNEL 3	
39	ADC CHANNEL 4	
40	ADC CHANNEL 5	
41	ADC CHANNEL 6	
42	ADC CHANNEL 7	
43	ERROR STATUS WORD (ESW) {CY?}	LSB
44		
45		
46		MSB
47	SPARE	
48		
49	PRESSURE	LSB
50		
51		
52		MSB
53	PRESSURE SENSOR VARIANCE	LSB
54		
55		
56		MSB
57	SPARE	
58	RTC CENTURY	
59	RTC YEAR	
60	RTC MONTH	
61	RTC DAY	
62	RTC HOUR	
63	RTC MINUTE	
64	RTC SECOND	
65	RTC HUNDREDTH	

See Table 33, page 134 for a description of the fields.

Figure 12. Variable Leader Data Format

Variable Leader data refers to the dynamic WorkHorse ADCP data (from clocks/sensors) that change with each ping. The WorkHorse ADCP always sends Variable Leader data as output data (LSBs first).

Table 33: Variable Leader Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	VID / Variable Leader ID	Stores the Variable Leader identification word (80 00h).

5-8	3,4	Ens / Ensemble Number	This field contains the sequential number of the ensemble to which the data in the output buffer apply.
			Scaling: LSD = 1 ensemble; Range = 1 to 65,535 ensembles
			NOTE: The first ensemble collected is #1. At "rollover," we have the following sequence:
			1 = ENSEMBLE NUMBER 1
			↓
			65535 = ENSEMBLE NUMBER 65,535 | ENSEMBLE
			0 = ENSEMBLE NUMBER 65,536 | #MSB FIELD
			1 = ENSEMBLE NUMBER 65,537 | (BYTE 12)
			INCR.

9,10	5	RTC Year	These fields contain the time from the WorkHorse ADCP's real-time clock (RTC) that the current data ensemble began. The TS-command (Set Real-Time Clock) initially sets the clock. The WorkHorse ADCP does account for leap years.
11,12	6	RTC Month	
13,14	7	RTC Day	
15,16	8	RTC Hour	
17,18	9	RTC Minute	
19,22	10	RTC Second	
21,22	11	RTC Hundredths	
23-24	12	Ensemble # MSB	This field increments each time the Ensemble Number field (bytes 3,4) "rolls over." This allows ensembles up to 16,777,215. See Ensemble Number field above.
25-28	13,14	BIT / BIT Result	This field contains the results of the WorkHorse ADCP's Built-in Test function. A zero code indicates a successful BIT result. BYTE 13 BYTE 14 (BYTE 14 RESERVED FOR FUTURE USE) 1xxxxxxx xxxxxxxx = RESERVED x1xxxxxx xxxxxxxx = RESERVED xx1xxxxx xxxxxxxx = RESERVED xxx1xxxx xxxxxxxx = DEMOD 1 ERROR xxxx1xxx xxxxxxxx = DEMOD 0 ERROR xxxxx1xx xxxxxxxx = RESERVED xxxxxx1x xxxxxxxx = TIMING CARD ERROR xxxxxxx1 xxxxxxxx = RESERVED
29-32	15,16	EC / Speed of Sound	Contains either manual or calculated speed of sound information (EC-command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s

Continued next page

Table 33: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
33-36	17,18	ED / Depth of Transducer	Contains the depth of the transducer below the water surface (ED-command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
37-40	19,20	EH / Heading	Contains the WorkHorse ADCP heading angle (EH-command). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
41-44	21,22	EP / Pitch (Tilt 1)	Contains the WorkHorse ADCP pitch angle (EP-command). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
45-48	23,24	ER / Roll (Tilt 2)	Contains the WorkHorse ADCP roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing WorkHorse ADCPs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing WorkHorse ADCPs, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
49-52	25,26	ES / Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
53-56	27,28	ET / Temperature	Contains the temperature of the water at the transducer head (ET-command). This value may be a manual setting or a reading from a temperature sensor. Scaling: LSD = 0.01 degree; Range = -5.00 to +40.00 degrees
57,58	29	MPT minutes	This field contains the Minimum Pre-Ping Wait Time between ping groups in the ensemble.
59,60	30	MPT seconds	
61,62	31	MPT hundredths	
63,64	32	H/Hdg Std Dev	These fields contain the standard deviation (accuracy) of the heading and tilt angles from the gyrocompass/pendulums.
65,66	33	P/Pitch Std Dev	
67,68	34	R/Roll Std Dev	Scaling (Heading): LSD = 1°; Range = 0 to 180° Scaling (Tilts): LSD = 0.1°; Range = 0.0 to 20.0°

Table 33: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
69-70	35	ADC Channel 0	These fields contain the outputs of the Analog-to-Digital Converter (ADC) located on the DSP board. The ADC sequentially samples one of the eight channels per ping group (the number of ping groups per ensemble is the maximum of the WP). These fields are zeroed at the beginning of the deployment and updated each ensemble at the rate of one channel per ping group. For example, if the ping group size is 5, then:
71-72	36	ADC Channel 1	
73-74	37	ADC Channel 2	
75-76	38	ADC Channel 3	
77-78	39	ADC Channel 4	
79-80	40	ADC Channel 5	
81-82	41	ADC Channel 6	
83-84	42	ADC Channel 7	

```
END OF ENSEMBLE No.      CHANNELS UPDATED
       Start             All channels = 0
         1               0, 1, 2, 3, 4
         2               5, 6, 7, 0, 1
         3               2, 3, 4, 5, 6
         4               7, 0, 8, 2, 3
         ↓                    ↓
```

Here is the description for each channel:

```
CHANNEL  DESCRIPTION
0        XMIT CURRENT
1        XMIT VOLTAGE
2        AMBIENT TEMP
3        PRESSURE (+)
4        PRESSURE (-)
5        ATTITUDE TEMP
6        ATTITUDE
7        CONTAMINATION SENSOR
```

Note that the ADC values may be “noisy” from sample-to-sample, but are useful for detecting long-term trends.

85-86	43	Error Status Word	Contains the long word containing the bit flags for the CY? Command. The ESW is cleared (set to zero) between each ensemble. Note that each number above represents one bit set – they may occur in combinations. For example, if the long word value is 0000C000 (hexadecimal), then it indicates that <u>both</u> a cold wake-up (0004000) and an unknown wake-up (00008000) occurred.

```
Low 16 BITS
LSB
BITS 07 06 05 04 03 02 01 00
     x  x  x  x  x  x  x  1  Bus Error exception
     x  x  x  x  x  x  1  x  Address Error exception
     x  x  x  x  x  1  x  x  Illegal Instruction exception
     x  x  x  x  1  x  x  x  Zero Divide exception
     x  x  x  1  x  x  x  x  Emulator exception
     x  x  1  x  x  x  x  x  Unassigned exception
     x  1  x  x  x  x  x  x  Watchdog restart occurred
     1  x  x  x  x  x  x  x  Battery Saver power
```

87-88	44	

```
Low 16 BITS
MSB
BITS 15 14 13 12 11 10 09 08
     x  x  x  x  x  x  x  1  Pinging
     x  x  x  x  x  x  1  x  Not Used
     x  x  x  x  x  1  x  x  Not Used
     x  x  x  x  1  x  x  x  Not Used
     x  x  x  1  x  x  x  x  Not Used
     x  x  1  x  x  x  x  x  Not Used
     x  1  x  x  x  x  x  x  Cold Wakeup occurred
     1  x  x  x  x  x  x  x  Unknown Wakeup occurred
```

89-90	45	

```
High 16 BITS
LSB
BITS 24 23 22 21 20 19 18 17
     x  x  x  x  x  x  x  1  Clock Read error occurred
     x  x  x  x  x  x  1  x  Unexpected alarm
     x  x  x  x  x  1  x  x  Clock jump forward
     x  x  x  x  1  x  x  x  Clock jump backward
     x  x  x  1  x  x  x  x  Not Used
     x  x  1  x  x  x  x  x  Not Used
     x  1  x  x  x  x  x  x  Not Used
     1  x  x  x  x  x  x  x  Not Used
```

Table 33: Variable Leader Data Format (continued)

Hex Digit	Binary Byte	Field	Description
91-92	46		High 16 BITS MSB BITS 32 31 30 29 28 27 26 25 x x x x x x x 1 Not Used x x x x x x 1 x Not Used x x x x x 1 x x Not Used x x x x 1 x x x Power Fail (Unrecorded) x x x 1 x x x x Spurious level 4 intr (DSP) x x 1 x x x x x Spurious level 5 intr (UART) x 1 x x x x x x Spurious level 6 intr (CLOCK) 1 x x x x x x x Level 7 interrupt occurred
93-96	47-48	Reserved	Reserved for TRDI use.
97-104	49-52	Pressure	Contains the pressure of the water at the transducer head relative to one atmosphere (sea level). Output is in deca-pascals (see "How Does the WorkHorse ADCP Sample Depth and Pressure?," page 138). Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
105-112	53-56	Pressure variance	Contains the variance (deviation about the mean) of the pressure sensor data. Output is in deca-pascals. Scaling: LSD=1 deca-pascal; Range=0 to 4,294,967,295 deca-pascals
113-114	57	Spare	Spare
115-116	58	RTC Century	These fields contain the time from the WorkHorse ADCP's Y2K compliant real-time clock (RTC) that the current data ensemble began. The TT-command (Set Real-Time Clock) initially sets the clock. The WorkHorse ADCP does account for leap years.
117-118	59	RTC Year	
119-120	60	RTC Month	
121-122	61	RTC Day	
123-124	62	RTC Hour	
125-126	63	RTC Minute	
127-128	64	RTC Seconds	
129-130	65	RTC Hundredths	

How Does the WorkHorse ADCP Sample Depth and Pressure?

a. For each ping, the ADC samples the pressure sensor five times and averages the data. This is an attempt to reduce the Standard Deviation.

b. Using the Pressure coefficients, the pressure data from the ADC is converted to kPa.

c. That data is converted to dm and corrected for salinity with the following equation:

   Depth (dm) = Pressure(kPa) * (1.02-0.00069*ES), where ES is the Salinity setting.

   This is the depth value recorded in the PD0 variable leader when the WH is fitted with a pressure sensor and that the EZ command is set to EZx1xxxxx.

d. The pressure data is converted from kPa to deca-Pascals by multiplying it by 100. This value in deca Pascals is recorded in the PD0 variable leader data.

Converting kpa to Depth

The formula for converting kpa to depth (using *WinADCP*) is as follows:

(kpa(1.02-0.00069*Salinity)*(1000/Water Density))/10

5.4 Velocity Data Format

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	VELOCITY ID								LSB 00h
2									MSB 01h
3	DEPTH CELL #1, VELOCITY 1								LSB
4									MSB
5	DEPTH CELL #1, VELOCITY 2								LSB
6									MSB
7	DEPTH CELL #1, VELOCITY 3								LSB
8									MSB
9	DEPTH CELL #1, VELOCITY 4								LSB
10									MSB
11	DEPTH CELL #2, VELOCITY 1								LSB
12									MSB
13	DEPTH CELL #2, VELOCITY 2								LSB
14									MSB
15	DEPTH CELL #2, VELOCITY 3								LSB
16									MSB
17	DEPTH CELL #2, VELOCITY 4								LSB
18									MSB
↓	(SEQUENCE CONTINUES FOR UP TO 128 CELLS)								↓
1019	DEPTH CELL #128, VELOCITY 1								LSB
1020									MSB
1021	DEPTH CELL #128, VELOCITY 2								LSB
1022									MSB
1023	DEPTH CELL #128, VELOCITY 3								LSB
1024									MSB
1025	DEPTH CELL #128, VELOCITY 4								LSB
1026									MSB

See Table 34, page 140 for description of fields

Figure 13. Velocity Data Format

NOTE. The number of depth cells is set by the WN-command.

The WorkHorse ADCP packs velocity data for each depth cell of each beam into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The WorkHorse ADCP scales velocity data in millimeters per second (mm/s). A value of –32768 (8000h) indicates bad velocity values.

All velocities are relative based on a stationary instrument. To obtain absolute velocities, algebraically remove the velocity of the instrument. For example,

```
RELATIVE WATER CURRENT VELOCITY:    EAST 650 mm/s
INSTRUMENT VELOCITY            : (-) EAST 600 mm/s
ABSOLUTE WATER VELOCITY        :     EAST  50 mm/s
```

The setting of the EX-command (Coordinate Transformation) determines how the WorkHorse ADCP references the velocity data as shown below.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
EX00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	TO BEAM 4
EX01xxx	INST	Bm1-Bm2	Bm4-Bm3	TO XDUCER	ERR VEL
EX10xxx	SHIP	PRT-STBD	AFT-FWD	TO SURFACE	ERR VEL
EX11xxx	EARTH	TO EAST	TO NORTH	TO SURFACE	ERR VEL

POSITIVE VALUES INDICATE WATER MOVEMENT TOWARD THE ADCP

For Horizontal ADCP systems, use the following table.

EX-CMD	COORD SYS	VEL 1	VEL 2	VEL 3	VEL 4
EX00xxx	BEAM	TO BEAM 1	TO BEAM 2	TO BEAM 3	0
EX01xxx	INST	X AXIS	Y AXIS	0	ERROR VEL
EX10xxx	SHIP	X AXIS	Y AXIS	VERTICAL	ERROR VEL (tilt applied)
EX11xxx	EARTH	EAST	NORTH	VERTICAL	ERROR VEL (heading applied)

POSITIVE VALUES INDICATE WATER MOVEMENT TOWARD THE ADCP

Table 34: Velocity Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Velocity ID	Stores the velocity data identification word (00 01h).
5-8	3,4	Depth Cell 1, Velocity 1	Stores velocity data for depth cell #1, velocity 1. See above.
9-12	5,6	Depth Cell 1, Velocity 2	Stores velocity data for depth cell #1, velocity 2. See above.
13-16	7,8	Depth Cell 1, Velocity 3	Stores velocity data for depth cell #1, velocity 3. See above.
17-20	9,10	Depth Cell 1, Velocity 4	Stores velocity data for depth cell #1, velocity 4. See above.
21-2052	11-1026	Cells 2 – 128 (if used)	These fields store the velocity data for depth cells 2 through 128 (depending on the setting of the WN-command). These fields follow the same format as listed above for depth cell 1.

5.5 Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

	BIT POSITIONS								
BYTE	7/S	6	5	4	3	2	1	0	
1	ID CODE								LSB
2									MSB
3	DEPTH CELL #1, FIELD #1								
4	DEPTH CELL #1, FIELD #2								
5	DEPTH CELL #1, FIELD #3								
6	DEPTH CELL #1, FIELD #4								
7	DEPTH CELL #2, FIELD #1								
8	DEPTH CELL #2, FIELD #2								
9	DEPTH CELL #2, FIELD #3								
10	DEPTH CELL #2, FIELD #4								
↓	(SEQUENCE CONTINUES FOR UP TO 128 BINS)								↓
511	DEPTH CELL #128, FIELD #1								
512	DEPTH CELL #128, FIELD #2								
513	DEPTH CELL #128, FIELD #3								
514	DEPTH CELL #128, FIELD #4								

See Table 35, page 142 through Table 37, page 144 for a description of the fields.

Figure 14. Correlation Magnitude, Echo Intensity, and Percent-Good Data Format

NOTE. The number of depth cells is set by the WN-command.

Correlation magnitude data give the magnitude of the normalized echo autocorrelation at the lag used for estimating the Doppler phase change. The WorkHorse ADCP represents this magnitude by a linear scale between 0 and 255, where 255 is perfect correlation (i.e., a solid target). A value of zero indicates bad correlation values.

Table 35: Correlation Magnitude Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the correlation magnitude data identification word (00 02h).
5,6	3	Depth Cell 1, Field 1	Stores correlation magnitude data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores correlation magnitude data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores correlation magnitude data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores correlation magnitude data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store correlation magnitude data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The echo intensity scale factor is about 0.45 dB per WorkHorse ADCP count. The WorkHorse ADCP does not directly check for the validity of echo intensity data.

Table 36: Echo Intensity Data Format

Hex Digit	Binary Byte	Field	Description
1 – 4	1,2	ID Code	Stores the echo intensity data identification word (00 03h).
5,6	3	Depth Cell 1, Field 1	Stores echo intensity data for depth cell #1, beam #1. See above.
7,8	4	Depth Cell 1, Field 2	Stores echo intensity data for depth cell #1, beam #2. See above.
9,10	5	Depth Cell 1, Field 3	Stores echo intensity data for depth cell #1, beam #3. See above.
11,12	6	Depth Cell 1, Field 4	Stores echo intensity data for depth cell #1, beam #4. See above.
13 – 1028	7 – 514	Cells 2 – 128 (if used)	These fields store echo intensity data for depth cells 2 through 128 (depending on the WN-command) for all four beams. These fields follow the same format as listed above for depth cell 1.

The percent-good data field is a data-quality indicator that reports the percentage (0 to 100) of good data collected for each depth cell of the velocity profile. The setting of the EX-command (Coordinate Transformation) determines how the WorkHorse ADCP references percent-good data as shown below.

EX-Command	Coordinate System	Velocity 1	Velocity 2	Velocity 3	Velocity 4
		Percentage Of Good Pings For:			
		Beam 1	BEAM 2	BEAM 3	BEAM 4
xxx00xxx	Beam	Percentage Of:			
xxx01xxx	Inst	3-Beam Transformations (note 1)	Transformations Rejected (note 2)	More Than One Beam Bad In Bin	4-Beam Transformations
xxx10xxx	Ship				
xxx11xxx	Earth				

1. Shows the percentage of successful velocity calculations (50%) using 3-beam solutions.
2. Shows percent of error velocity (5%) that was higher than the WE-command setting.

At the start of the velocity profile, the backscatter echo strength is typically high on all four beams. Under this condition, the WorkHorse ADCP uses all four beams to calculate the orthogonal and error velocities. As the echo returns from far away depth cells, echo intensity decreases. At some point, the echo will be weak enough on any given beam to cause the WorkHorse ADCP to reject some of its depth cell data. This causes the WorkHorse ADCP to calculate velocities with three beams instead of four beams. When the WorkHorse ADCP does 3-beam solutions, it stops calculating the error velocity because it needs four beams to do this. At some further depth cell, the WorkHorse ADCP rejects all cell data because of the weak echo. As an example, let us assume depth cell 60 has returned the following percent-good data.

```
FIELD #1 = 50, FIELD #2 = 5, FIELD #3 = 0, FIELD #4 = 45
```

If the EX-command was set to collect velocities in BEAM coordinates, the example values show the percentage of pings having good solutions in cell 60 for each beam based on the Low Correlation Threshold (WC-command). Here, beam 1=50%, beam 2=5%, beam 3=0%, and beam 4=45%. These are not typical nor desired percentages. Typically, you would want all four beams to be about equal and greater than 25%.

On the other hand, if velocities were collected in INSTRUMENT, SHIP, or EARTH coordinates, the example values show:

FIELD 1 – Percentage of good 3-beam solutions – Shows percentage of successful velocity calculations (50%) using 3-beam solutions.

FIELD 2 – Percentage of transformations rejected – Shows percent of error velocity (5%) that was higher than the WE-command setting. WE has a default of 5000 mm/s. This large WE setting effectively prevents the Workhorse from rejecting data based on error velocity.

FIELD 3 – Percentage of more than one beam bad in bin – 0% of the velocity data were rejected because not enough beams had good data.

FIELD 4 – Percentage of good 4-beam solutions – 45% of the velocity data collected during the ensemble for depth cell 60 were calculated using four beams.

Table 37: Percent-Good Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the percent-good data identification word (00 04h).
5,6	3	Depth cell 1, Field 1	Stores percent-good data for depth cell #1, field 1. See above.
7,8	4	Depth cell 1, Field 2	Stores percent-good data for depth cell #1, field 2. See above.
9,10	5	Depth cell 1, Field 3	Stores percent-good data for depth cell #1, field 3. See above.
11,12	6	Depth cell 1, Field 4	Stores percent-good data for depth cell #1, field 4. See above.
13-1028	7-514	Depth cell 2 – 128 (if used)	These fields store percent-good data for depth cells 2 through 128 (depending on the WN-command), following the same format as listed above for depth cell 1.

5.6 Bottom-Track Data Format

BYTE	BIT POSITIONS 7/S	6	5	4	3	2	1	0	
1	BOTTOM-TRACK ID								LSB 00h
2									MSB 06h
3	BT PINGS PER ENSEMBLE {BP}								LSB
4									MSB
5	BT DELAY BEFORE RE-ACQUIRE {BD}								LSB
6									MSB
7	BT CORR MAG MIN {BC}								
8	BT EVAL AMP MIN {BA}								
9	BT PERCENT GOOD MIN {BG}								
10	BT MODE {BM}								
11	BT ERR VEL MAX {BE}								LSB
12									MSB
13	RESERVED								
14									
15									
16									
17	BEAM#1 BT RANGE								LSB
18									MSB
19	BEAM#2 BT RANGE								LSB
20									MSB
21	BEAM#3 BT RANGE								LSB
22									MSB
23	BEAM#4 BT RANGE								LSB
24									MSB
25	BEAM#1 BT VEL								LSB
26									MSB
27	BEAM#2 BT VEL								LSB
28									MSB
29	BEAM#3 BT VEL								LSB
30									MSB
31	BEAM#4 BT VEL								LSB
32									MSB

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33	BEAM#1 BT CORR.	
34	BEAM#2 BT CORR.	
35	BEAM#3 BT CORR.	
36	BEAM#4 BT CORR.	
37	BEAM#1 EVAL AMP	
38	BEAM#2 EVAL AMP	
39	BEAM#3 EVAL AMP	
40	BEAM#4 EVAL AMP	
41	BEAM#1 BT %GOOD	
42	BEAM#2 BT %GOOD	
43	BEAM#3 BT %GOOD	
44	BEAM#4 BT %GOOD	
45	REF LAYER MIN {BL}	LSB
46		MSB
47	REF LAYER NEAR {BL}	LSB
48		MSB
49	REF LAYER FAR {BL}	LSB
50		MSB
51	BEAM#1 REF LAYER VEL	LSB
52		MSB
53	BEAM #2 REF LAYER VEL	LSB
54		MSB
55	BEAM #3 REF LAYER VEL	LSB
56		MSB
57	BEAM #4 REF LAYER VEL	LSB
58		MSB
59	BM#1 REF CORR	
60	BM#2 REF CORR	
61	BM#3 REF CORR	
62	BM#4 REF CORR	
63	BM#1 REF INT	
64	BM#2 REF INT	
65	BM#3 REF INT	
66	BM#4 REF INT	

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67	BM#1 REF %GOOD	
68	BM#2 REF %GOOD	
69	BM#3 REF %GOOD	
70	BM#4 REF %GOOD	
71	BT MAX. DEPTH {BX}	LSB
72		MSB
73	BM#1 RSSI AMP	
74	BM#2 RSSI AMP	
75	BM#3 RSSI AMP	
76	BM#4 RSSI AMP	
77	GAIN	
78	(*SEE BYTE 17)	MSB
79	(*SEE BYTE 19)	MSB
80	(*SEE BYTE 21)	MSB
81	(*SEE BYTE 23)	MSB
82	RESERVED	
83		
84		
85		

Figure 15. Bottom-Track Data Format

NOTE. This data is output only if the BP-command is > 0 and PD0 is selected. See Table 38, page 148 for a description of the fields.

NOTE. The PD0 output data format assumes that the **instrument** is stationary and the **bottom** is moving. DVL (Speed Log) output data formats (see "Special Output Data Formats," page 151) assume that the bottom is stationary and that the ADCP or vessel is moving.

NOTE. Bottom Track is a feature upgrade for WorkHorse ADCP Monitor and Sentinel ADCPs (see "Feature Upgrades," page 5).

NOTE. Bottom Track is not available for Long Ranger ADCPs.

This data is output only if the BP-command is greater than zero and PD0 is selected. The LSB is always sent first.

Table 38: Bottom-Track Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	ID Code	Stores the bottom-track data identification word (00 06h).
5-8	3,4	BP/BT Pings per ensemble	Stores the number of bottom-track pings to average together in each ensemble (BP-command). If BP = 0, the ADCP does not collect bottom-track data. The ADCP automatically extends the ensemble interval (TE) if BP x TP > TE.
			Scaling: LSD = 1 ping; Range = 0 to 999 pings
9-12	5,6	BD/BT delay before reacquire	Stores the number of ADCP ensembles to wait after losing the bottom before trying to reacquire it (BD-command).
			Scaling: LSD = 1 ensemble; Range = 0 to 999 ensembles
13,14	7	BC/BT Corr Mag Min	Stores the minimum correlation magnitude value (BC-command).
			Scaling: LSD = 1 count; Range = 0 to 255 counts
15,16	8	BA/BT Eval Amp Min	Stores the minimum evaluation amplitude value (BA-command).
			Scaling: LSD = 1 count; Range = 1 to 255 counts
17,18	9	BG/BT %Gd Minimum	Stores the minimum percentage of bottom-track pings in an ensemble that must be good to output velocity data (BG-command).
19,20	10	BM/BT Mode	Stores the bottom-tracking mode (BM-command).
21-24	11,12	BE/BT Err Vel Max	Stores the error velocity maximum value (BE-command).
			Scaling: LSD = 1 mm/s; Range = 0 to 5000 mm/s (0 = did not screen data)
25-32	13–16	Reserved	Reserved
33-48	17-24	BT Range/Beam #1-4 BT Range	Contains the two lower bytes of the vertical range from the ADCP to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range = 0. See bytes 78 through 81 for MSB description and scaling.
			Scaling: LSD = 1 cm; Range = 0 to 65535 cm
49-64	25-32	BT Velocity/Beam #1-4 BT Vel	The meaning of the velocity depends on the EX (coordinate system) command setting. The four velocities are as follows:
			a) Beam Coordinates: Beam 1, Beam 2, Beam 3, Beam 4
			b) Instrument Coordinates: 1->2, 4->3, toward face, error
			c) Ship Coordinates: Starboard, Fwd, Upward, Error
			d) Earth Coordinates: East, North, Upward, Error
65-72	33-36	BTCM/Beam #1-4 BT Corr.	Contains the correlation magnitude in relation to the sea bottom (or surface) as determined by each beam. Bottom-track correlation magnitudes have the same format and scale factor as water-profiling magnitudes (Table 5).

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Table 38: Bottom-Track Data Format (continued)

Hex Digit	Binary Byte	Field	Description
73-80	37-40	BTEA/Beam #1-4	Contains the evaluation amplitude of the matching filter used in determining the strength of the bottom echo.
		BT Eval Amp	Scaling: LSD = 1 count; Range = 0 to 255 counts
81-88	41-44	BTPG/Beam #1-4 BT %Good	Contains bottom-track percent-good data for each beam, which indicate the reliability of bottom-track data. It is the percentage of bottom-track pings that have passed the ADCP's bottom-track validity algorithm during an ensemble.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
89-92 93-96 97 – 100	45,46 47,48 49,50	Ref Layer (Min, Near, Far)	Stores the minimum layer size, the near boundary, and the far boundary of the BT water-reference layer (BL-command).
			Scaling (minimum layer size): LSD = 1 dm; Range = 0-999 dm
			Scaling (near/far boundaries): LSD = 1 dm; Range = 0-9999 dm
101-116	51-58	Ref Vel/Beam #1-4 Ref Layer Vel	Contains velocity data for the water reference layer for each beam. Reference layer velocities have the same format and scale factor as water-profiling velocities (Table 34, page 140). The BL-command explains the water reference layer.
117-124	59-62	RLCM/Bm #1-4 Ref Corr	Contains correlation magnitude data for the water reference layer for each beam. Reference layer correlation magnitudes have the same format and scale factor as water-profiling magnitudes (Table 5).
125-132	63-66	RLEI/Bm #1-4 Ref Int	Contains echo intensity data for the reference layer for each beam. Reference layer intensities have the same format and scale factor as water-profiling intensities.
133-140	67-70	RLPG/Bm #1-4 Ref %Good	Contains percent-good data for the water reference layer for each beam. They indicate the reliability of reference layer data. It is the percentage of bottom-track pings that have passed a reference layer validity algorithm during an ensemble.
			Scaling: LSD = 1 percent; Range = 0 to 100 percent
141-144	71,72	BX/BT Max. Depth	Stores the maximum tracking depth value (BX-command).
			Scaling: LSD = 1 decimeter; Range = 80 to 9999 decimeters
145-152	73-76	RSSI/Bm #1-4 RSSI Amp	Contains the Receiver Signal Strength Indicator (RSSI) value in the center of the bottom echo as determined by each beam.
			Scaling: LSD ≈ 0.45 dB per count; Range = 0 to 255 counts
153, 154	77	GAIN	Contains the Gain level for shallow water. See WJ-command.
155-162	78-81	BT Range MSB/Bm #1-4	Contains the most significant byte of the vertical range from the ADCP to the sea bottom (or surface) as determined by each beam. This vertical range does not consider the effects of pitch and roll. When bottom detections are bad, BT Range=0. See bytes 17 through 24 for LSB description and scaling.
			Scaling: LSD = 65,536 cm, Range = 65,536 to 16,777,215 cm
163-170	82-85	Reserved	Reserved

5.7 Reserved BIT Data Format

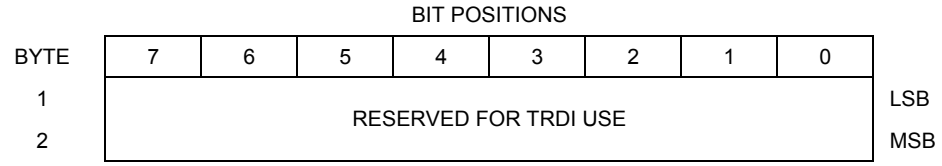

Figure 16. Reserved BIT Data Format

NOTE. The data is always output in this format. See Table 39 for a description of the fields.

Table 39: Reserved for TRDI Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Reserved for TRDI's use	This field is for TRDI (internal use only).

5.8 Checksum Data Format

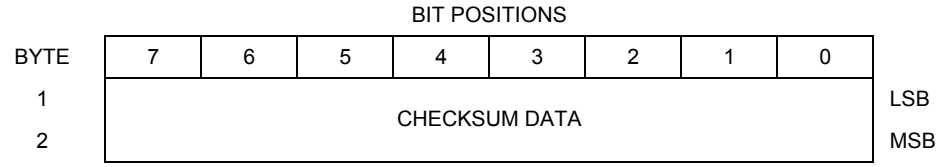

Figure 17. Checksum Data Format

NOTE. The data is always output in this format. See Table 40 for a description of the fields.

Table 40: Checksum Data Format

Hex Digit	Binary Byte	Field	Description
1-4	1,2	Checksum Data	This field contains a modulo 65535 checksum. The Work-Horse ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum.

6 Special Output Data Formats

The PD3, PD4, PD5, PD6, PD9, and PD10, commands select the desired DVL (speed log) output data format. PD8 and PD9 are special ASCII output data formats. PD12 is a reduced data output format. PD14 is a condensed 2D output format for H-ADCPs only. The PD15 Output Data Format is designed for NDBC satellite data links. PD16 and PD18 are for use with Sea-Bird acoustic modems.

The DVL binary output data buffers can contain header, configuration, bottom-velocity, water-mass reference-layer, range to bottom, status, built-in test, sensor, and distance made good data (plus a checksum). The ADCP collects all data in the output buffer during an ensemble.

Figure 18, page 153 through Figure 20, page 162 shows the format of these buffers and the sequence in which the ADCP sends the data. Table 41, page 154 through Table 46, page 173 list the format, bytes, fields, scaling factors, and a detailed description of every item in the DVL binary output buffers.

NOTE. The DVL output data formats are available with or without bottom-track. However, if bottom-track is not available, they will contain no data.

NOTE. The DVL output data formats assume that the bottom is stationary and that the ADCP or vessel is moving. The PD0 Bottom Track output data format (see "Bottom-Track Data Format," page 145) assumes that the instrument is stationary and the bottom is moving.

6.1 DVL Data Format (PD3)

	BIT POSITION								
Byte	7	6	5	4	3	2	1	0	
1	DVL DATA ID 7Eh								
2	DATA STRUCTURE*								
3	STARBOARD/EAST VELOCITY (With Respect To BTM)								LSB
4									MSB
5	FORWARD/NORTH VELOCITY (With Respect To BTM)								LSB
6									MSB
7	UPWARD VELOCITY (With Respect To BTM)								LSB
8									MSB
9	STARBOARD/EAST VELOCITY (With Respect To WATER REF)								LSB
10									MSB
11	FORWARD/NORTH VELOCITY (With Respect To WATER REF)								LSB
12									MSB
13	UPWARD VELOCITY (With Respect To WATER REF)								LSB
14									MSB
15	BM1 RNG TO BTM								LSB
16									MSB
17	BM2 RNG TO BTM								LSB
18									MSB
19	BM3 RNG TO BTM								LSB
20									MSB
21	BM4 RNG TO BTM								LSB
22									MSB
23	RANGE TO BTM (AVERAGE)								LSB
24									MSB
25	SPARE								
↓									↓
↓									↓
40									

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41	SENSOR/OTHER DATA	
42	PING TIME: HOUR	
43	MINUTE	
44	SECOND	
45	HUNDREDTH	
46	HEADING	LSB
47		MSB
48	PITCH	LSB
49		MSB
50	ROLL	LSB
51		MSB
52	TEMPERATURE	LSB
53		MSB
54	BIT RESULTS	LSB
55		MSB
56	CHECKSUM	LSB
57		MSB

Figure 18. DVL Data Format (PD3)

6.2 DVL Output Data Format (PD3) Details

The ADCP sends this data format only when the PD3 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

Table 41: DVL Output Data Format (PD3) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Eh)
3,4	2	Reserved	Reserved
5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, then Ship coordinates are used. If the data bit is set to 1, then Earth coordinates are used. These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
9-12	5,6	Y-Vel Btm	
13-16	7,8	Z-Vel Btm	† Bit #1: Vertical velocities.
17-20	9,10	X-Vel Water	† Bit #2: These fields contain the velocity of the vessel in relation to the water reference layer in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
21-24	11,12	Y-Vel Water	
25-28	13,14	Z-Vel Water	† Bit #1 and Bit #2
29-32	15,16	Bm1	† Bit #3: These fields contain the vertical range from the ADCP to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm
45-48	23,24	Avg Rng to Btm	† Bit #4: These fields contain the average vertical range from the ADCP to the bottom as determined by each beam.

Continued next page

Table 41: DVL Output Data Format (PD3) Details (continued)

Hex Digit	Binary Byte	Field	Description
49-80	25-40	Spare	Spare
81,82	41	Sensor/Other Data	† Output if Bit #7 of "Data to Follow" byte is set. These fields contain the Sensor/Other data. Bit # 0 = Time 1 = Heading 2 = Pitch 3 = Roll 4 = Temperature 5 = Active Built-In-Test
83-90	42,43	Time: HH,MM	‡ Sensor/Other Data Bit #0: These fields contains the time of the ping in Hours, Minutes
			Seconds, Hundredths of seconds respectively.
	44,45	Time: SS,HH	
91-94	46,47	Heading	‡ Sensor/Other Data Bit #1: this field contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: this field contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: this field contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: this field contains the Temperature in hundredths of degrees.
107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: this field contains the Built-In-Test results. Each bit specifies the result of built-in-test during an ensemble. If the bit is set, the test failed. BYTE 54 BYTE 55 (BYTE 55 RESERVED FOR FUTURE USE) 1xxxxxxx xxxxxxxx = RESERVED x1xxxxxx xxxxxxxx = RESERVED xx1xxxxx xxxxxxxx = RESERVED xxx1xxxx xxxxxxxx = DEMOD 1 ERROR xxxx1xxx xxxxxxxx = DEMOD 0 ERROR xxxxx1xx xxxxxxxx = RESERVED xxxxxx1x xxxxxxxx = DSP ERROR xxxxxxx1 xxxxxxxx = RESERVED
111-114	56,57	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

NOTES.

† This block of data is only output if the bit is set in the Data to Follow byte.

‡ This block of data is only output if the bit is set in the Sensor/Other Data byte.

6.3 DVL Data Format (PD4/PD5)

	BIT POSITION								
Byte	7	6	5	4	3	2	1	0	
1	DVL DATA ID 7Dh								
2	DATA STRUCTURE*								
3	NO. OF BYTES								LSB
4									MSB
5	SYSTEM CONFIG								
6	X-VEL BTM								LSB
7									MSB
8	Y-VEL BTM								LSB
9									MSB
10	Z-VEL BTM								LSB
11									MSB
12	E-VEL BTM								LSB
13									MSB
14	BM1 RNG TO BTM								LSB
15									MSB
16	BM2 RNG TO BTM								LSB
17									MSB
18	BM3 RNG TO BTM								LSB
19									MSB
20	BM4 RNG TO BTM								LSB
21									MSB
22	BOTTOM STATUS								
23	X-VEL REF LAYER								LSB
24									MSB
25	Y-VEL REF LAYER								
26									
27	Z-VEL REF LAYER								
28									

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29 30	E-VEL REF LAYER
31 32	REF LAYER START
33 34	REF LAYER END
35	REF LAYER STATUS
36	TOFP-HOUR
37	TOFP-MINUTE
38	TOFP-SECOND
39	TOFP-HUNDREDTHS
40 41	BIT RESULTS
42 43	SPEED OF SOUND
44 45	TEMPERATURE
46 47	CHECKSUM

Figure 19. DVL Data Format (PD4/PD5)

NOTES.

*If 0, then PD4 (Bytes 1-47)

*If 1, then PD5 (Bytes 1-45 + Table 43, page 163)

6.4 DVL Output Data Format (PD4/PD5) Details

The ADCP sends this data format only when the PD4 or PD5 command is used.

Table 42: DVL Output Data Format (PD4/PD5) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (7Dh).
3,4	2	Data Structure	Identifies which data pattern will follow based on the PD-command. 0 = PD4 = Bytes 1 through 47 from Figure 19, page 157. 1 = PD5 = Bytes 1 through 45 from Figure 19, page 157 and bytes 46 through 88 from Figure 20, page 162. Note: PD6 is ASCII-only; see Table 44, page 164.
5-8	3,4	No. of Bytes	Contains the number of bytes sent in this data structure, not including the final checksum.
9,10	5	System Config	Defines the DVL hardware/firmware configuration. Convert to binary and interpret as follows. BIT 76543210 00xxxxxx BEAM-COORDINATE VELOCITIES 01xxxxxx INSTRUMENT-COORDINATE VELOCITIES 10xxxxxx SHIP-COORDINATE VELOCITIES 11xxxxxx EARTH-COORDINATE VELOCITIES xx0xxxxx TILT INFORMATION NOT USED IN CALCULATIONS xx1xxxxx TILT INFORMATION USED IN CALCULATIONS xxx0xxxx 3-BEAM SOLUTIONS NOT COMPUTED xxx1xxxx 3-BEAM SOLUTIONS COMPUTED xxxxx010 300-kHz DVL xxxxx011 600-kHz DVL xxxxx100 1200-kHz DVL
11-14	6,7	X-Vel Btm	These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to east (X), north (Y), and up (Z). LSD = 1 mm/s (see NOTES at end of this table).
15-18	8,9	Y-Vel Btm	
19-22	10,11	Z-Vel Btm	
23-26	12,13	E-Vel Btm	
27-30	14,15	Bm1	These fields contain the vertical range from the ADCP to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
31-34	16,17	Bm2 Rng to	
35-38	18,19	Bm3 Bottom	
39-42	20,21	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm

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Table 42: DVL Output Data Format (PD4/PD5) Details (continued)

Hex Digit	Binary Byte	Field	Description
43,44	22	Bottom Status	This field shows the status of bottom-referenced correlation and echo amplitude data. Convert to binary and interpret as follows. A zero code indicates status is OK. BIT 76543210 1xxxxxxx BEAM 4 LOW ECHO AMPLITUDE x1xxxxxx BEAM 4 LOW CORRELATION xx1xxxxx BEAM 3 LOW ECHO AMPLITUDE xxx1xxxx BEAM 3 LOW CORRELATION xxxx1xxx BEAM 2 LOW ECHO AMPLITUDE xxxxx1xx BEAM 2 LOW CORRELATION xxxxxx1x BEAM 1 LOW ECHO AMPLITUDE xxxxxxx1 BEAM 1 LOW CORRELATION
45-48	23,24	X-Vel Ref Layer	These fields contain the velocity of the vessel in relation to the water-mass reference layer in mm/s. Positive values indicate vessel motion to east (X), north (Y), and up (Z). LSD = 1 mm/s (See NOTES at end of this table.)
49-52	25,26	Y-Vel Ref Layer	
53-56	27,28	Z-Vel Ref Layer	
57-60	29,30	E-Vel Ref Layer	
61-64	31,32	Ref Layer Start	These fields contain the starting boundary (near surface) and the ending boundary (near bottom) of the water-mass reference layer (BL-command). If the minimum size field is zero, the ADCP does not calculate reference-layer data. Scaling: LSD = 1 dm; Range = 0-9999 dm
65-68	33,34	Ref Layer End	
69,70	35	Ref Layer Status	This field shows the status of reference layer depth and correlation data. Convert to binary and interpret as follows. A zero code indicates status is OK. BIT 76543210 xxx1xxxx ALTITUDE IS TOO SHALLOW xxxx1xxx BEAM 4 LOW CORRELATION xxxxx1xx BEAM 3 LOW CORRELATION xxxxxx1x BEAM 2 LOW CORRELATION xxxxxxx1 BEAM 1 LOW CORRELATION
71,72	36	TOFP Hour	These fields contain the time of the first ping of the current ensemble.
73,74	37	TOFP Minute	
75,76	38	TOFP Second	
77,78	39	TOFP Hundredth	
79-82	40,41	BIT Results	These fields contain the results of the ADCP's Built-in Test function. A zero code indicates a successful BIT result. BYTE 40 BYTE 41 (BYTE 41 RESERVED FOR FUTURE USE) 1xxxxxxx xxxxxxxx = RESERVED x1xxxxxx xxxxxxxx = RESERVED xx1xxxxx xxxxxxxx = RESERVED xxx1xxxx xxxxxxxx = DEMOD 1 ERROR xxxx1xxx xxxxxxxx = DEMOD 0 ERROR xxxxx1xx xxxxxxxx = RESERVED xxxxxx1x xxxxxxxx = DSP ERROR xxxxxxx1 xxxxxxxx = RESERVED
83-86	42,43	Speed of Sound	Contains either manual or calculated speed of sound information (EC-command). Scaling: LSD = 1 meter per second; Range = 1400 to 1600 m/s
87-90	44,45	Temperature	Contains the temperature of the water at the transducer head. Scaling: LSD = 0.01 C; Range = -5.00 to +40.00 C

Table 42: DVL Output Data Format (PD4/PD5) Details (continued)

Hex Digit	Binary Byte	Field	Description
91-94	46,47	Checksum	This field contains a modulo 65536 checksum. The ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum. NOTE: This field contains the checksum only when the PD4-command is used. If PD5 is used, the remaining bytes are explained in Table 43, page 163.

NOTES.

The ADCP packs velocity data into a two-byte, two's-complement integer [-32768, 32767] with the LSB sent first. The ADCP scales velocity data in millimeters per second (mm/s). A value of –32768 (8000h) indicates a bad velocity.

Bottom or reference-layer velocities will be all valid or all invalid. That is, if the X-velocity is valid then the Y and Z-velocities are valid; if X is not valid, Y and Z are not valid.

The ADCP allows 3-beam transformations when the fourth beam is invalid. Indication of a 3-beam transformation for bottom-track is valid bottom velocities and one and only one beam's range to bottom is marked bad (zero).

There is no indication that a 3-beam transformation was performed for water reference layer velocity data.

6.5 DVL Data Format (PD5)

	BIT POSITION								
Byte	7	6	5	4	3	2	1	0	
46	SALINITY								
47	DEPTH								LSB
48									MSB
49	PITCH								LSB
50									MSB
51	ROLL								LSB
52									MSB
53	HEADING								LSB
54									MSB
55	DISTANCE MADE GOOD/BTM (EAST)								LSB
56									
57									
58									MSB
59	DISTANCE MADE GOOD/BTM (NORTH)								LSB
60									
61									
62									MSB
63	DISTANCE MADE GOOD/BTM (UP)								LSB
64									
65									
66									MSB
67	DISTANCE MADE GOOD/BTM (ERROR)								LSB
68									
69									
70									MSB
71	DISTANCE MADE GOOD/REF (EAST)								LSB
72									
73									
74									MSB

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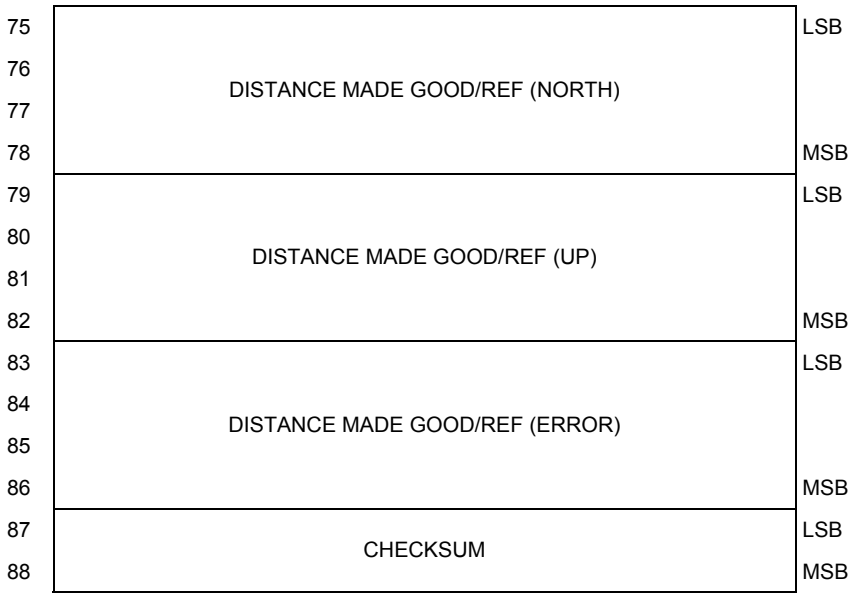

Figure 20. DVL Data Format (PD5)

6.6 DVL Output Data Format (PD5) Details

The ADCP sends this data format (Figure 19, page 157 and Figure 20, page 162) only when the PD5 command is used. Table 42, page 158 explains the first part of this data structure.

Table 43: DVL Output Data Format (PD5) Details

Hex Digit	Binary Byte	Field	Description
91,92	46	Salinity	Contains the salinity value of the water at the transducer head (ES-command). This value may be a manual setting or a reading from a conductivity sensor. Scaling: LSD = 1 part per thousand; Range = 0 to 40 ppt
93-96	47,48	Depth	Contains the depth of the transducer below the water surface (ED-command). This value may be a manual setting or a reading from a depth sensor. Scaling: LSD = 1 decimeter; Range = 1 to 9999 decimeters
97-100	49,50	Pitch	Contains the ADCP pitch angle (EP-command). This value may be a manual setting or a reading from a tilt sensor. Positive values mean that Beam #3 is spatially higher than Beam #4. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
101-104	51,52	Roll	Contains the ADCP roll angle (ER-command). This value may be a manual setting or a reading from a tilt sensor. For up-facing ADCPs, positive values mean that Beam #2 is spatially higher than Beam #1. For down-facing ADCPs, positive values mean that Beam #1 is spatially higher than Beam #2. Scaling: LSD = 0.01 degree; Range = -20.00 to +20.00 degrees
105-108	53,54	Heading	Contains the ADCP heading angle (EH-command). This value may be a manual setting or a reading from a heading sensor. Scaling: LSD = 0.01 degree; Range = 000.00 to 359.99 degrees
109-116	55-58	DMG/Btm East	These fields contain the Distance Made Good (DMG) over the bottom since the time of the first ping after initialization or <BREAK>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
117-124	59-62	DMG/Btm North	
125-132	63-66	DMG/Btm Up	
133-140	67-70	DMG/Btm Error	
141-148	71-74	DMG/Ref East	These fields contain the distance made good over the water-mass reference layer since the time of the first ping after initialization or <BREAK>. Scaling: LSD = 1 dm; Range = -10,000,000 to 10,000,000 dm
149-156	75-78	DMG/Ref North	
157-164	79-82	DMG/Ref Up	
165-172	83-86	DMG/Ref Error	
173-176	87,88	Checksum	This field contains a modulo 65536 checksum. The ADCP computes the checksum by summing all the bytes in the output buffer excluding the checksum.

6.7 DVL Output Data Format (PD6)

The ADCP sends this data format only when the PD6 command is used. The ADCP outputs data in the following line order. The ADCP may not sent all data lines. Examples: (1) If BK = zero, the ADCP does not send water-mass data (line items beginning with W); (2) If BK = three, the ADCP does not send bottom-track data (line items beginning with B).

Table 44: DVL Output Data Format (PD6)

Line	Description
1	**SYSTEM ATTITUDE DATA** **:SA,±PP.PP,±RR.RR,HH.HH <CR><LF>** where: PP.PP = Pitch in degrees RR.RR = Roll in degrees HHH.HH = Heading in degrees
2	**TIMING AND SCALING DATA** **:TS,YYMMDDHHmmsshh,SS.S,+TT.T,DDDD.D,CCCC.C,BBB <CR><LF>** where: YYMMDDHHmmsshh = Year, month, day, hour, minute, second, hundredths of seconds SS.S = Salinity in parts per thousand (ppt) TT.TT = Temperature in C DDDD.D = Depth of transducer face in meters CCCC.C = Speed of sound in meters per second BBB = Built-in Test (BIT) result code
3	**WATER-MASS, INSTRUMENT-REFERENCED VELOCITY DATA** **:WI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis vel. data in mm/s (+ = Bm1 Bm2 xdcr movement relative to water mass) ±YYYYY = Y-axis vel. data in mm/s (+ = Bm4 Bm3 xdcr movement relative to water mass) ±ZZZZZ = Z-axis vel. data in mm/s (+ = transducer movement away from water mass) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
4	**WATER-MASS, SHIP-REFERENCED VELOCITY DATA** **:WS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement rel. to water mass) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement rel. to water mass) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from water mass) S = Status of velocity data (A = good, V = bad)
5	**WATER-MASS, EARTH-REFERENCED VELOCITY DATA** **:WE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = ADCP movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = ADCP movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = ADCP movement to surface) S = Status of velocity data (A = good, V = bad)

Continued next page

Table 44: DVL Output Data Format (PD6) (continued)

Line	Description
6	**WATER-MASS, EARTH-REFERENCED DISTANCE DATA** **:WD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to water-mass center in meters TTT.TT = Time since last good-velocity estimate in seconds
7	**BOTTOM-TRACK, INSTRUMENT-REFERENCED VELOCITY DATA** **:BI,±XXXXX,±YYYYY,±ZZZZZ,±EEEEE,S <CR><LF>** where: ±XXXXX = X-axis velocity data in mm/s (+ = Bm1 Bm2 xdcr movement relative to bottom) ±YYYYY = Y-axis velocity data in mm/s (+ = Bm4 Bm3 xdcr movement relative to bottom) ±ZZZZZ = Z-axis velocity data in mm/s (+ = transducer movement away from bottom) ±EEEEE = Error velocity data in mm/s S = Status of velocity data (A = good, V = bad)
8	**BOTTOM-TRACK, SHIP-REFERENCED VELOCITY DATA** **:BS,±TTTTT,±LLLLL,±NNNNN,S <CR><LF>** where: ±TTTTT = Transverse vel. data in mm/s (+ = Port Stbd ship movement relative to bottom) ±LLLLL = Longitudinal vel. data in mm/s (+ = Aft Fwd ship movement relative to bottom) ±NNNNN = Normal velocity data in mm/s (+ = ship movement away from bottom) S = Status of velocity data (A = good, V = bad)
9	**BOTTOM-TRACK, EARTH-REFERENCED VELOCITY DATA** **:BE,±EEEEE,±NNNNN,±UUUUU,S <CR><LF>** where: ±EEEEE = East (u-axis) velocity data in mm/s (+ = ADCP movement to east) ±NNNNN = North (v-axis) velocity data in mm/s (+ = ADCP movement to north) ±UUUUU = Upward (w-axis) velocity data in mm/s (+ = ADCP movement to surface) S = Status of velocity data (A = good, V = bad)
10	**BOTTOM-TRACK, EARTH-REFERENCED DISTANCE DATA** **:BD,±EEEEEEEE.EE,±NNNNNNNN.NN,±UUUUUUUU.UU,DDDD.DD,TTT.TT <CR><LF>** where: +EEEEEEEE.EE = East (u-axis) distance data in meters +NNNNNNNN.NN = North (v-axis) distance data in meters +UUUUUUUU.UU = Upward (w-axis) distance data in meters DDDD.DD = Range to bottom in meters TTT.TT = Time since last good-velocity estimate in seconds

The PD6 output does not pad spaces with zeroes. The spaces are left intact. The example below shows a realistic output from a WorkHorse ADCP locked onto the bottom.

```
:SA,  -2.31,  +1.92, 75.20
:TS,04081111563644,35.0,+21.0,   0.0,1524.0,  0
:WI,-32768,-32768,-32768,-32768,V
:BI,   +24,    -6,   -20,    -4,A
:WS,-32768,-32768,-32768,V
:BS,   -13,   +21,   -20,A
:WE,-32768,-32768,-32768,V
:BE,   +17,   +18,   -20,A
:WD,       +0.00,       +0.00,       +0.00,  20.00,  0.00
:BD,       -0.02,       -0.03,       +0.02,   7.13,  0.21
```

6.8 PD8 ASCII Output

The ADCP sends this data format only when the PD8 command is used. PD8 outputs ensemble data as formatted text. A new-line character terminates each line. Two new-line characters terminate an ensemble.

PD8 data is only for serial output. If you select PD8 and set the CF command to CFxxx01 (recorder on), the ADCP will output PD8 ASCII data out the serial port and record PD0 data to the recorder card. You can then use the PD0 data to troubleshoot any setup problems with the ADCP.

```
1997/02/28 11:16:50.07 00001
Hdg: 209.1 Pitch: 9.6 Roll: -9.1
Temp: 22.8 SoS: 1529 BIT: 00
Bin    Dir    Mag     E/W     N/S    Vert     Err   Echo1  Echo2  Echo3  Echo4
  1     --     --  -32768  -32768  -32768  -32768     43     49     46     43
  2     --     --  -32768  -32768  -32768  -32768     44     41     45     44
  3     --     --  -32768  -32768  -32768  -32768     43     41     45     43
  4     --     --  -32768  -32768  -32768  -32768     43     41     46     43
  5     --     --  -32768  -32768  -32768  -32768     43     41     45     43
  6     --     --  -32768  -32768  -32768  -32768     42     41     46     43
  7     --     --  -32768  -32768  -32768  -32768     43     42     46     43
  8     --     --  -32768  -32768  -32768  -32768     43     40     46     43
  9     --     --  -32768  -32768  -32768  -32768     43     41     45     44
 10     --     --  -32768  -32768  -32768  -32768     44     41     46     44
```

If all four beams have good data, then direction and magnitude are output as well.

CAUTION. PD8 output data format can not be recorded – it must be output through the serial port only. Do not use this output data format for a self-contained deployment.

6.9 PD9 ASCII Output

PD9 is a water-profiling format meant to collect data in earth coordinates and formatted for easy parsing. All fields are fixed width, comma separated, and either zero or space padded.

The header information of Date, Time, Temp, Heading, and Tilts total is 55 bytes. The water-profiling information is 34 bytes per bin of data.

```
CCYY/MM/DD,HH:mm:ss,
T:ttt.t,H:ddd.d,P:+pp.p,R:+rr.r,
nnn,+vvvvv,+vvvvv,+vvvvv,+vvvvv,
.
.
.
nnn,+vvvvv,+vvvvv,+vvvvv,+vvvvv,
```

-Repeated for each ensemble-

Where

Field	Description
CC	= Fixed length (zero padded) Century
YY	= Fixed length (zero padded) Year
MM	= Fixed length (zero padded) Month
DD	= Fixed length (zero padded) Day of Month
HH	= Fixed length (zero padded) Hour
mm	= Fixed length (zero padded) Minutes
ss	= Fixed length (zero padded) Seconds
T:	= Signifies Temperature.
ttt.t	= Fixed length (space padded) Temperature in Deg C.
H:	= Signifies Heading.
ddd.d	= Fixed length (space padded) Heading in Deg.
P:	= Signifies Pitch.
+pp.p	= Fixed length (space padded) signed Pitch in Deg.
R:	= Signifies Roll.
+rr.r	= Fixed length (space padded) signed Roll in Deg.
nnn	= Fixed length (zero padded) Bin Number.
+vvvvv	= Fixed length (zero padded) signed velocity in mm/s. Beam, Inst, Ship or Earth.

Example

```
1999/04/08,14:53:04,
T: 24.3,H:185.4,P: -3.5,R: +6.7,
001,-00577,+00974,-00044,-00622,
002,-01589,-01546,-00157,+00182,
003,-00404,-00338,-00132,-00290,
004,-01055,-00931,+00103,-00004,
005,+00280,+01290,-00655,+00339,
006,+00538,+00714,+00738,+00825,
007,+01825,+00025,+00397,+00160,
008,+00371,+01181,+01169,+00892,
009,-00218,-00716,+00627,+00375,
010,-00979,+03923,-00452,-00038,
...
090,-00990,-04774,+00925,-00457,
091,-05175,-04205,+00541,+00201,
092,-06582,+01245,+00581,-00802,
093,-03221,-00999,+00141,-00467,
094,-02362,-04466,+00572,-00204,
095,-04809,-08065,+01812,-01061,
096,-08233,+04324,+02969,-00893,
097,-01679,-03700,-00573,+00401,
098,+01733,+04916,-00325,-00520,
099,-05380,+00337,-00599,-00943,
100,-00702,+03590,+00358,+00955,
```

6.10 DVL Data Format (PD10)

BYTE	BIT POSITION								
	7	6	5	4	3	2	1	0	
1	DVL DATA ID 78h								
2	DATA STRUCTURE*								
3	STARBOARD/EAST VELOCITY (With Respect To BTM)								LSB
4									MSB
5	FORWARD/NORTH VELOCITY (With Respect To BTM)								LSB
6									MSB
7	UPWARD VELOCITY (With Respect To BTM)								LSB
8									MSB
9	STARBOARD/EAST VELOCITY (With Respect To WATER REF)								LSB
10									MSB
11	FORWARD/NORTH VELOCITY (With Respect To WATER REF)								LSB
12									MSB
13	UPWARD VELOCITY (With Respect To WATER REF)								LSB
14									MSB
15	BM1 RNG TO BTM								LSB
16									MSB
17	BM2 RNG TO BTM								LSB
18									MSB
19	BM3 RNG TO BTM								LSB
20									MSB
21	BM4 RNG TO BTM								LSB
22									MSB
23	RANGE TO BTM (AVERAGE)								LSB
24									MSB
25 ↓ ↓ 40	SPARE								↓ ↓
41	SENSOR/OTHER DATA								
42	PING TIME : HOUR								
43	MINUTE								
44	SECOND								
45	HUNDREDTH								
46	HEADING								LSB
47									MSB

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BYTE	BIT POSITION								
	7	6	5	4	3	2	1	0	
48	PITCH								LSB
49									MSB
50	ROLL								LSB
51									MSB
52	TEMPERATURE								LSB
53									MSB
54	BIT RESULTS								LSB
55									MSB
56	DEPTH								LSB
57									
58									
59									MSB
60	DEPTH STANDARD DEVIATION								LSB
61									
62									
63									MSB
64	CHECKSUM								LSB
65									MSB

Figure 21. DVL Data Format (PD10)

NOTE. PD10 Output Data Format is not available for WorkHorse ADCP Monitor/Sentinel systems with 8.xx firmware.

6.11 DVL Output Data Format (PD10) Details

The ADCP/DVL sends this data format only when the PD10 command is used. In multiple byte parameters, the least significant byte always comes before the more significant bytes.

NOTE. PD10 Output Data Format is not available for WorkHorse ADCP Monitor/Sentinel systems with 8.xx firmware.

Table 45: DVL Output Data Format (PD10) Details

Hex Digit	Binary Byte	Field	Description
1,2	1	DVL Data ID	Stores the DVL (speed log) identification word (78h)
3,4	2	Reserved	Reserved
5-8	3,4	X-Vel Btm	† Bit #0: Always output. If the data bit is set to 0, then Ship coordinates are used. If the data bit is set to 1, then Earth coordinates are used. These fields contain the velocity of the vessel in relation to the bottom in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, and (Z) Upward.
9-12	5,6	Y-Vel Btm	
13-16	7,8	Z-Vel Btm	† Bit #1: Vertical velocities.
17-20	9,10	X-Vel Water	† Bit #2: These fields contain the velocity of the vessel in relation to the water reference layer in mm/s. Positive values indicate vessel motion to (X) Starboard/East, (Y) Forward/North, (Z) Upward.
21-24	11,12	Y-Vel Water	
25-28	13,14	Z-Vel Water	† Bit #1 and Bit #2
29-32	15,16	Bm1	† Bit #3: These fields contain the vertical range from the ADCP to the bottom as determined by each beam. This vertical range does not compensate for the effects of pitch and roll. When a bottom detection is bad, the field is set to zero.
33-36	17,18	Bm2 Rng to	
37-40	19,20	Bm3 Bottom	
41-44	21,22	Bm4	Scaling: LSD = 1 centimeter; Range = 0 to 65535 cm

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Table 45: DVL Output Data Format (PD10) Details (continued)

Hex Digit	Binary Byte	Field	Description
45-48	23,24	Avg Rng to Btm	† Bit #4: These fields contain the average vertical range from the ADCP to the bottom as determined by each beam.
49-80	25-40	Spare	Spare
81,82	41	Sensor/Other Data	† Output if Bit #7 of "Data to Follow" byte is set. These fields contain the Sensor/Other data. Bit # 0 = Time 1 = Heading 2 = Pitch 3 = Roll 4 = Temperature 5 = Active Built-In-Test
83-90	42,43	Time: HH,MM	‡ Sensor/Other Data Bit #0: These fields contains the time of the ping in Hours, Minutes
			Seconds, Hundredths of seconds respectively.
	44,45	Time: SS,HH	
91-94	46,47	Heading	‡ Sensor/Other Data Bit #1: These fields contains the Heading in hundredths of degrees.
95-98	48,49	Pitch	‡ Sensor/Other Data Bit #2: These fields contains the Pitch in hundredths of degrees.
99-102	50,51	Roll	‡ Sensor/Other Data Bit #3: These fields contains the Roll in hundredths of degrees.
103-106	52,53	Temp	‡ Sensor/Other Data Bit #4: These fields contains the Temperature in hundredths of degrees.
107-110	54,55	BIT results	‡ Sensor/Other Data Bit #5: These fields contains the Built-In-Test results. Each bit specifies the result of built-in-test during an ensemble. If the bit is set, the test failed. BYTE 54 BYTE 55 (BYTE 55 RESERVED FOR FUTURE USE) 1xxxxxxx xxxxxxxx = RESERVED x1xxxxxx xxxxxxxx = RESERVED xx1xxxxx xxxxxxxx = RESERVED xxx1xxxx xxxxxxxx = DEMOD 1 ERROR xxxx1xxx xxxxxxxx = DEMOD 0 ERROR xxxxx1xx xxxxxxxx = RESERVED xxxxxx1x xxxxxxxx = DSP ERROR xxxxxxx1 xxxxxxxx = RESERVED
111-118	56-59	Depth	Depth data in decimeters.
119-126	60-63	Depth Std Dev.	Standard deviation of depth in decimeters
127-130	64,65	Checksum	This is the 16-bit checksum of all the preceding binary bytes.

6.12 Reduced Data Output Format (PD12)

The PD12 format is suitable for use in applications where communications bandwidth is an issue, such as acoustic modems and radio modems. Setting PD12 enables the reduced data output format. Each ensemble shall be output according to Table 46, page 173. Data will continue to be recorded in the standard PD0 format. All data will be in Intel (little-endian) binary format.

Velocity data will be output according to the PB and PO commands. The PB command determines which velocity bins are output, while the PO command determines which velocity components are to be output. Each selected bin requires two bytes per velocity component. All of the selected bins for each component will be output contiguously. Only the components selected by the PO command will be output.

The **ensemble size** is a function of the parameters supplied by the PB command, the number of data types selected by the PO command, and the number of bins selected for recording by the WN command. The ensemble size will vary as shown below.

x = start bin (first parameter of PB command)
y = number of bins for output (second parameter of PB command)
z = sub-sampling parameter (third parameter of PB command)
d = number of data types (from the PO command)
n = number of bins for recording (WN command)

If $0 < y < ((n - x) / z)$:

Size = $34 + 2 * d * y$

Otherwise:

Size = $34 + 2 * d * ((n - x) / z)$

The size calculated above is the value reported in the Size field of the ensemble format. It does not include the checksum.

The **Unit ID field** of the PD12 format is used to allow each ADCP in a network of instruments to uniquely identify itself. The field is one byte wide and is set by the CI command.

To further assist in bandwidth conservation, the CH command has been added to allow **suppression of the wakeup message**. If CH1 is saved to the user command set (via the CK command), the unit will only output a ">" when a break is sent or power is applied. It should be noted that much of the software provided by TRDI for interfacing with the ADCP relies on keywords in the wakeup banner to distinguish one type of ADCP from another. Suppression of the wakeup banner may cause this software to fail or function erratically. CH should be left at its factory default unless the user

is certain that suppression of the wakeup banner will not interfere with the operation of the instrument.

Table 46: Reduced Data Output Format (PD12)

Location	Size	Field	Description
0	2	ID	Always 7F6E.
2	2	Size	Size of ensemble in bytes including ID but not including checksum.
4	4	Number	Ensemble Number
8	1	Unit ID	The ID of the ADCP as set by the CI command.
9	1	FW Vers	CPU Firmware Version.
10	1	FW Rev	CPU Firmware Revision.
11	2	Year	4-digit year of ensemble time-stamp.
13	1	Month	Month (1 – 12) of ensemble time-stamp.
14	1	Day	Day of month (1 – 31) of ensemble time-stamp.
15	1	Hour	Hour (0 – 23) of ensemble time-stamp.
16	1	Minute	Minute (0 – 59) of ensemble time-stamp.
17	1	Second	Second (0 - 59) of ensemble time-stamp.
18	1	Hsec	Hundredths of seconds (0 - 99) of ensemble time-stamp.
19	2	Heading	Heading in units of 0.01 °.
21	2	Pitch	Pitch in units of 0.01 °.
23	2	Roll	Roll in units of 0.01 °.
25	2	Temp	Temperature in units of 0.01 °C
27	4	Pressure	Pressure in 0.01 kPa

31	1	Components	Bits 0-3 contain the velocity component flags of the PO command.
			Bits 4-7 contain the bin subsampling parameter of the PB command
			`bit 7 6 5 4 3 2 1 0`
			`x x x x 1 x x x component 4`
			`x x x x x 1 x x component 3`
			`x x x x x x 1 x component 2`
			`x x x x x x x 1 component 1`
			`n n n n x x x x sub-sampling parameter`

32	1	Start Bin	The first bin parameter from the PB command.
33	1	Bins	The number of bins parameter from the PB command.
34	2**N***D*	Data	Velocity data. *N* = number of bins. *D* = number of velocity components selected.
34 + 2**N***D*	2	Checksum	Checksum.

6.13 Output Data Format (PD15)

The PD15 Output Data Format is designed for NDBC satellite data links. It contains the same data as the PD0 format; however the binary data is re-mapped using a special algorithm onto the 7-bit ASCII character set. This is done by taking groups of three 8-bit binary bytes (24 data bits), and re-packaging them into four 8-bit bytes (32 bits) where the most significant two bits in each encoded byte are set to "01", and the least significant six bits in each encoded byte contain the original data. A <CR> is then added at end of the ensemble. The reverse algorithm needs to be applied on the host end to decode the PD15 data into its original PD0 form.

Here is an example (shown both in hex and binary) of how the PD0 data is encoded to product the PD15 format (each group of three PD0 bytes are encoded into four PD15 bytes):

Hex:

```
PD0: 7F 7F 12 34 56 78    ==>    PD15: 5F 77 7C 52 4D 45 59 78"
```

Binary:

```
PD0:  01111111 01111111 00010010 00110100 01010110 01111000 ==>
PD15: 01011111 01110111 01111100 01010010 01001101 01000101 01011001
01111000
```

6.14 Output Data Format (PD16)

CAUTION. PD16 will **NOT** output data when the system is in Beam Coordinates (see "EX – Coordinate Transformation," page 51). The data has to have been transformed to output meaningful data.

NOTE. When configured for PD16 and recording data to the recorder (CF11111), CS will start outputting data even if the card is full or missing.

The current generation of Sea-Bird acoustic modems uses the '$' as a command terminator. This prevents them from handling the NMEA standard messages which all start with the '$' character. Consequently, the current PD16 format is:

PRDIK,sn,yyddmm,hhmmss.ss,b_1,m_1,d_1,b_2,m_2,d_2,…,b_n,m_n,d_n*xx<cr><lf>

Where:

sn	= Serial Number
yyddmm	= Date
hhmmss.ss	= Time
b_x	= Bin Number
m_x	= Magnitude
d_x	= Direction
xx	= NMEA checksum

- In the event of bad data, the appropriate field will be left empty, with the commas present to indicate the absence of data.
- The bins to be displayed are selected using the PB command as in the case of PD12.
- The maximum length for the message is 480 bytes.

NOTE. Sea-Bird Electronics has acknowledged that they have a problem and are said to be changing their firmware to support the NMEA standard. At that time, use PD18 to meet the NMEA standard.

6.15 Output Data Format (PD18)

PD18 is the same Output Data Format as PD16, but with the leading '$' necessary to fully comply with the NMEA format.

CAUTION. PD18 will **NOT** output data when the system is in Beam Coordinates (see "EX – Coordinate Transformation," page 51). The data has to have been transformed to output meaningful data.

NOTE. When configured for PD18 and recording data to the recorder (CF11111), CS will start outputting data even if the card is full or missing.

7 How to Decode an ADCP Ensemble

Use the following information to help you write your own software.

7.1 Rules for the BroadBand Data Format PD0

a. All data types (i.e. fixed leader, variable leader, velocity, echo intensity, correlation, percent good, etc.) will be given a specific and unique ID number. The table below shows some of the most common IDs.

Table 47: Common Data Format IDs

ID	Description
0x7F7F	Header
0x0000	Fixed Leader
0x0080	Variable Leader
0x0100	Velocity Profile Data
0x0200	Correlation Profile Data
0x0300	Echo Intensity Profile Data
0x0400	Percent Good Profile Data
0x0500	Status Profile Data
0x0600	Bottom Track Data
0x0800	MicroCAT Data

b. Once a data type has been given an ID number and the format of that data has been published we consider the format for each field has being fixed. Fixed refers to units used for a given field, the number of bytes in a given field, and the order in which the fields appear within the data type. Fixed does not refer to the total number of bytes in the data type - see Rule “c”.

c. Data may be added to an existing data type only by adding the bytes to the end of the data format. As an example, the variable leader data contains information on ensemble number, time, heading, pitch, roll, temperature, pressure, etc. The format for the bytes 1-53 are now specified by changes added in support to the WorkHorse ADCP. If additional sensor data is to be added to the variable leader data then it must be added to the end of the data string (bytes 54-x as an example).

d. The order of data types in an ensemble is not fixed. That is there is no guarantee that velocity data will always be output before correlation data.

e. The header data will include the number of data types in the files and the offset to each ID number for each data type.

f. The total number of the bytes in an ensemble minus the 2-byte checksum will be included in the header.

7.2 Recommended Data Decoding Sequence for BroadBand Data Format PD0

a. Locate the header data by locating the header ID number (in the case of PD0 profile data that will be 7F7F).

b. Confirm that you have the correct header ID by:

   1. Locating the total number of bytes (located in the header data) in the ensemble. This will be your offset to the next ensemble.
   2. Calculate the checksum of total number of bytes in the ensemble excluding the checksum. The checksum is calculated by adding the value of each byte. The 2-byte least significant digits that you calculate will be the checksum.
   3. Read the 2-byte checksum word at the end of the ensemble, located by using the checksum offset in the header (determined in step "b-1") and compare this checksum word to the value calculated in step "b-2".
   4. If the checksums match then you have a valid ensemble. If the checksums do not match then you do not have a valid ensemble and you need to go back to step "a" and search for the next header ID number occurrence.

c. Locate the number of data types (located in the header data).

d. Locate the offset to each data type (located in the header data).

e. Locate the data ID type you wish to decode by using the offset to each data type and confirm the data ID number at that offset matches the ID type you are looking for.

f. Once the proper ID type has been located, use the ADCP Technical Manual for the ADCP you are using to understand what each byte represents in that particular data type.

7.3 Pseudo-Code for Decoding PD0 Ensemble Data

The following examples show the pseudo-code for decoding PD0 and PD5 ensemble data.

g. Define structures, which contain all fields in all data types of the PD0 format.

   1. typedef struct { <lists of types and fields> } FixedLeader.
   2. typedef struct { <lists of types and fields> } VariableLeader.

3. typedef struct { <lists of types and fields> } BottomTrack.
4. typedef struct { <lists of types and fields> } VelocityType
5. and so on for every available type.

h. Clear checksum.

i. Look for PD0 ID 0x7F. Add to checksum.

j. Is next byte a 0x7F? Add to checksum.

k. If no, return to step “b”.

l. Else, read next two bytes to determine offset to checksum. Add two bytes to checksum.

m. Read in X more bytes, where X = offset to checksum - 4. Adding all bytes to checksum.

n. Read in checksum word.

o. Do checksums equal?

p. If no, return to “b”.

q. For each available data type (the header contains the # of data types), go to the offset list in header.

1. Create a pointer to type short to the data type at an offset in the list.
2. Check the Type ID.
3. Create a pointer of appropriate type to that location.
4. Repeat for all available data types.

r. Work with data.

s. Return to “b” for next ensemble.

7.4 Pseudo-Code for Decoding PD5 Ensemble Data

a. Define structure that contains all fields in PD5 format.

1. typedef struct { <lists of types and fields> } PD5_Format.

b. Clear checksum.

c. Look for ID, PD5 id is 0x7D. Add to checksum.

d. Is next byte a 0x01? Add to checksum.

e. If no, return to “b”.

f. Else, read next two bytes to determine offset to checksum. Add two bytes to checksum.

g. Read in X more bytes, where X = offset to checksum - 4. Adding all bytes to checksum.

h. Read in checksum word.

i. Do checksums equal?

j. If no, return to “b”.

k. Create a pointer of type PD5_Format.

   1. PD5_Format *PD5_ptr;

l. Point pointer at location of ID byte.

   1. PD5_ptr = &buf[<location of input buffer>];

m. If “k” and “l” don't appeal to you, you can create a variable of type PD5_Format.

   1. PD5_Format PD5_data;

n. And copy the data from the input buffer to PD5_data.

o. Work with data.

p. Return to “b” for next ensemble.

7.5 Example Code for Decoding BroadBand Ensembles

Here is an example of how to decode a BroadBand ensemble. It is written in “C.”

NOTE. Structures must be “packed”; i.e. Don’t let the compiler add “fill bytes” to align fields on word boundaries.

This is an example of a section of code, not a full executable program.

```
/*************************************************************************/
/* Data ID Words */
/*************************************************************************/

   #define FLdrSelected   0x0000
   #define VLdrSelected   0x0080
   #define VelSelected    0x0100
   #define CorSelected    0x0200
   #define AmpSelected    0x0300
   #define PctSelected    0x0400
   #define SttSelected    0x0500
   #define BotSelected    0x0600
   #define Prm0           0x0700

   #define VelGood        0x0701
   #define VelSum         0x0702
   #define VelSumSqr      0x0703
   #define Bm5VelSelected 0x0A00
   #define Bm5CorSelected 0x0B00
   #define Bm5AmpSelected 0x0C00
   #define AmbientData    0x0C02
   #define Bm5PctSelected 0x0D00
   #define Bm5SttSelected 0x0E00
   #define Prm0_5         0x1300
   #define VelGood_5      0x1301
```

```
   #define VelSum_5       0x1302
   #define VelSumSqr_5    0x1303

/*************************************************************************/
/* structures */
/*************************************************************************/

   typedef unsigned char  uchar;
   typedef unsigned short ushort;
   typedef unsigned long  ulong;

   typedef struct {
      uchar        Minute,
                   Second,
                   Sec100;
   }  TimeType;

   typedef struct {
      uchar        Year,
                   Month,
                   Day,
                   Hour,
                   Minute,
                   Second,
                   Sec100;
   }  DateTimeType;

   typedef struct {
      uchar        Version,
                   Revision;
   }  VersionType;

   typedef struct {
      uchar        ID,
                   DataSource;
      ushort       ChecksumOffset;
      uchar        Spare,
                   NDataTypes;
      ushort       Offset [256];
   }  HeaderType;

   typedef struct {
      ushort       ID;
      VersionType  CPUFirmware;
      ushort       Configuration;
      uchar        DummyDataFlag,
                   Lag,
                   NBeams,
                   NBins;
      ushort       PingsPerEnsemble,
                   BinLength,
                   BlankAfterTransmit;
      uchar        ProfilingMode,
                   PctCorrelationLow,
                   NCodeRepetitions,
                   PctGoodMin;
      ushort       ErrVelocityMax;
      TimeType     TimeBetweenPings;
      uchar        CoordSystemParms;
      short        HeadingAlignment,
                   HeadingBias;
      uchar        SensorSource,
                   AvailableSensors;
      ushort       DistanceToBin1Middle,
                   TransmitLength;
   }  FixLeaderType;

   typedef struct {
      ushort       ID,
                   EnsembleNumber;

      DateTimeType RecordingTime;
      uchar        Spare1;
      ushort       BITResult,
                   SpeedOfSound,
                   Depth,
                   Heading;
      short        Pitch,
```

```
                Roll;
   ushort       Salinity;
   short        Temperature;
   TimeType     MaxTimeBetweenPings;
   uchar        HeadingStddev,
                PitchStddev,
                RollStddev;
   uchar        VMeas [8];
}  VarLeaderType;

typedef struct {
   ushort       ID,
                PingsPerEnsemble,
                EnsembleDelay;
   uchar        CorrelationMin,
                AmplitudeMin,
                PctGoodMin,
                BTMode;
   ushort       ErrVelocityMax,
                NSearchPings,
                NTrackPings;
   ushort       Range        [4];
   short        Velocity     [4];
   uchar        Correlation  [4],
                Amplitude    [4],
                PctGood      [4];
   ushort       WaterLayerMin,
                WaterLayerNear,
                WaterLayerFar;
   short        WVelocity    [4];
   uchar        WCorrelation [4],
                WAmplitude   [4],
                WPctGood     [4];
   ushort       MaxTrackingDepth;
   uchar        Amp [4];
   uchar        Gain;
   uchar        RangeMSB [4];
}  BottomTrackType;

typedef struct
{
  ushort        ID;
  short         Data [256];
} OneBeamShortType;

typedef struct
{
  ushort        ID;
  uchar         Data [256];
} OneBeamUcharType;

typedef struct {
   ushort       ID;
   short        Data [1024];
}  IntStructType;

typedef struct {
   ushort       ID;
   uchar        Data [1024];
}  ByteStructType;

typedef struct
{
  ushort        ID;
  uchar         Data [4];
}  AmbientType;

typedef struct
{
  ushort        ID;
  ushort        UaH;
  ushort        UaL;
  ushort        AmbBitsPerBin;
  ushort        AmbTrys;
  ushort        AmbNBins;
  short         AmbBinNum [ 5 ];
  short         Est [ 5 ];
  ushort        WAutoCor [ 5 ] [ 32 ];
```

```
      uchar         SysFreq;
      uchar         SampRate;
   }  T01Type;

   typedef struct
   {
     ushort        ID;
     uchar         DAC [36];
   }  T02Type;

   typedef struct
   {
     ushort        ID;
     ushort        RSSIBinLen;
     ushort        RSSIBins;
     uchar         RSSI [512] [4];
     ushort        AutoCor [32] [4];
     short         Est [4];
     ushort        Amb [4];
     uchar         SysFreq;
     uchar         SampRate;
     uchar         MLen;
     ushort        XmtSamples;
     ushort        FirstBin[4];
     ushort        LastBin[4];
     ulong         BM6Depth[4];
     ushort        BM6Ta[4];
   }  T03Type;

/*************************************************************************/
/* Global Pointers */
/*************************************************************************/
   HeaderType       *HdrPtr;
   FixLeaderType    *FLdrPtr;
   VarLeaderType    *VLdrPtr;
   BottomTrackType  *BotPtr;
   BottomTrackType  *WBotPtr;
   IntStructType    *VelPtr;
   ByteStructType   *CorPtr;
   ByteStructType   *AmpPtr;
   ByteStructType   *PctPtr;
   ByteStructType   *SttPtr;
   AmbientType      *AmbientPtr;
   T01Type          *T01Ptr;
   T02Type          *T02Ptr;
   T03Type          *T03Ptr;
   OneBeamShortType *Bm5VelPtr;
   OneBeamUcharType *Bm5CorPtr;
   OneBeamUcharType *Bm5AmpPtr;
   OneBeamUcharType *Bm5PctPtr;
   OneBeamUcharType *Bm5SttPtr;

/*-----------------------------------------------------------------------*/

unsigned char RcvBuff[8192];


void DecodeBBensemble( void )
{
    unsigned short i, *IDptr, ID;

    FLdrPtr = (FixLeaderType *)&RcvBuff [ HdrPtr->Offset[0] ];

    if (FLdrPtr->NBins > 128)
        FLdrPtr->NBins = 32;

    for (i=1; i<HdrPtr->NDataTypes; i++)
    {
        IDptr = (unsigned short *)&RcvBuff [ HdrPtr->Offset [i] ];
        ID = IDptr[0];

        switch (ID)
        {
        case VLdrSelected:
            {
                VLdrPtr = (VarLeaderType *)&RcvBuff [ HdrPtr->Offset [i] ];
                break;
            }
```

```
            case VelSelected:
                {
                    VelPtr = (IntStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case CorSelected :
                {
                    CorPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case AmpSelected :
                {
                    AmpPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case PctSelected :
                {
                    PctPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case SttSelected :
                {
                    SttPtr = (ByteStructType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case BotSelected :
                {
                    BotPtr = (BottomTrackType*)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            case AmbientData :
                {
                    AmbientPtr = (AmbientType *)&RcvBuff [ HdrPtr->Offset [i] ];
                    break;
                }
            }
        }
    }
```

8 Firmware History

```
---------1---------2---------3---------4---------5---------6-----
         Workhorse Monitor/Sentinel Firmware History
                     as of:  02-NOV-2007
               ================================
               Current Firmware Version:  16.30

------------------------------------------------------------------
UPGRADE NOTES:
 When upgrading Workhorse firmware:
 1. You can upgrade your CPU firmware yourself by downloading the
    latest version from our Web/FTP sites.  Documentation is
    included with the self-extracting file that explains how to
    do this.  The file name you want to download has the
    following format:

                                  [System Type][Description].exe

    For example:  WHMSLFRM.EXE contains the files needed to
    upgrade the Workhorse Monitor/Sentinel CPU firmware to
    the latest version.
------------------------------------------------------------------
Version 16.05 (24APR2000 - 28JUN2000):
 -WorkHorse 16.05 is functionally identical to 8.33 with the
    following exceptions.

 -Added TT-command - Set Real-Time Clock (Y2k compliant).  Format
  TTccyymmdd,hhmmss where cc = century.  All other items are the
  same as the TS command.

 -Binary Variable Leader Data Format - added bytes 57 to 65 to show
  the TT-command.
  57 - Spare
  58 - RTC Century
  59 - RTC Year
  60 - RTC Month
  61 - RTC Day
  62 - RTC Hour
  63 - RTC Minute
  64 - RTC Second
  65 - RTC Hundredth

 -Added the TG-command - Time of First Ping (Y2k compliant).  Format
  TGccyymmdd,hhmmss where cc = century.  All other items are the same
  as the TF command.

 -Binary Fixed Leader Data Format - added bytes 51 to 53
  51 to 52 - System Bandwidth {WB}.  Contains the WB-command setting.
  Range 0 to 1
  53 - System power {CQ}.  Contains the CQ-command setting.  CQ only
  effects Long Ranger ADCPs.  Range 0 to 255.

 -Added the CX-command - Low Latency Trigger Enable
  Purpose - Enables or disables the low latency trigger.
  Format - CXnRange - n = 0 (off), n = 1 (on)
  Description - Turning on the Low Latency Trigger functionality allows
  the Workhorse to ping within ~100µs of the falling edge of the trigger.
  This function inhibits the ability of the Workhorse to sleep and
  conserve power.
  Recommended Setting - CX0. Use only when power consumption is not an
  issue.

 -Added Bottom Mode 6 (BM6 command) (for 2400kHz ADCPs)

 -Added PD10 format. PD10 is the same as PD3, but the ID number is 0x78
  and includes two new variables; Depth and Depth Standard Deviation
```

```
  (both in decimeters).  See the Expert Command Guide for documentation
  on this output data format (available June 2000).

 -Added troubleshooting capability to the PD8 format.  PD8 data is only
  for serial output.  If you select PD8 and set the CF command to
  CFxxx01 (recorder on), the ADCP will output PD8 ASCII data out the
  serial port and record PD0 data to the recorder card.  You can then
  use the PD0 data to troubleshoot any setup problems with the ADCP.
------------------------------------------------------------------
Version 16.06 (28JUN2000 - 21AUG2000):
 -Fixed a bug which corrupted the TimeBetweenWaveRecords, in the
  output structure only.
 -Fixed bug in Waves Loop which didn't update ADC values in Variable
  Leader at every ping.
------------------------------------------------------------------
Version 16.07 (21AUG2000 - 21NOV2000):
 -Added Data Format 'PD12'.  Added CI, PB, PE, and PO commands
  for use with 'PD12'.  For complete documentation, please contact
  RDI Customer Service.
 -Added 'CH' Command, which supresses the wakeup banner from
  being displayed when a break is sent or power is applied.
    Format:         CHx
    Range:          0 or 1, 0 = default.
    Description:    If CH1 is saved as part of the user command
                    set, the unit will not output a banner on
                    wakeup.  The unit will still output the '>'
                    prompt.
------------------------------------------------------------------
Version 16.08 (21NOV2000 - 05DEC2000):
 -Fixed a bug that could cause features to be lost when upgrading from
  8.xx to 16.xx.
------------------------------------------------------------------
Version 16.09 (05DEC2000 - 12DEC2000):
 -Fixed a bug that caused invalid checksum for PD12 format when
  using binary output.
------------------------------------------------------------------
Version 16.10 (12DEC2000 - 13DEC2000):
 -Fixed a bug that prevented the Temperature Offset from being restored
  from the Non-volatile storage.
------------------------------------------------------------------
Version 16.11 (13DEC2000 - 20DEC2000):
 -Fixed a bug which caused Temperature and Pressure to be removed
  from the PD12 data stream, and caused Heading, Pitch & Roll to
  be corrupted in the PD12 Data Stream.
------------------------------------------------------------------
Version 16.12 (20DEC2000 - 16APR2001):
 -Fixed a bug which makes the beam angle corrections appear lost,
  when they are not loaded.
------------------------------------------------------------------
Version 16.13 (internal release - never shipped):
------------------------------------------------------------------
Version 16.14 (internal release - never shipped):
------------------------------------------------------------------
Version 16.15 (16APR2001 - 16MAY2001):
 -Fixed bug that caused ADC channels not to be updated in variable
  leader when no bottom-track or profile pings were selected.
 -Fixed bug that prevented time between waves pings from being
  identical to time between profile pings.
------------------------------------------------------------------
Version 16.08 (16MAY2001 - 21MAY2001):
 -Reverted to 16.08 due to a bug in Bottom Track mode 5 that caused
  complete loss of bottom track data.
------------------------------------------------------------------
Version 16.16 (21MAY2001 - 10AUG2001)
 -Fixed bug that caused no water mass pings to be performed when
  Bottom Mode 5 was selected.
 -Fixed bug that caused potential loss of bottom track data when
  Bottom Mode 5 was selected.
```

```
------------------------------------------------------------------
Version 16.17 (10AUG2001 - 12OCT2001)
 -Fixed typo in display of Wave Gauge Acquisition in OL menu.
 -Fixed bug that caused pressure sensor coefficients to be
  overwritten when upgrading from 16.07 or earlier to 16.08 or
  later.
 -Fixed bug that caused bad velocities to be reported in PD12
  format when beam coordinates were selected.
 -Fixed bug that caused both PD12 and PD0 to be recorded when
  PD12 was selected.
 -Fixed display of allowable ranges for BX command.
------------------------------------------------------------------
Version 16.18 (07SEP2001 - 12OCT2001)(limited release)
 -Added CE command to allow user to retrieve last ensemble.
 -Added RD command to allow users to open and close deployment
  files.
 -Added RI command to allow user to prevent a deployment file from
  being closed when a break is sent.
------------------------------------------------------------------
Version 16.19 (07SEP2001 - 12OCT2001)
 -Added Water Mode 12, a high ping rate profile mode available as
  a feature upgrade.
 -Added Bottom Mode 7, a shallow bottom track mode available as a
  feature upgrade.
 -Fixed bottom track bug that could cause a Mode 5 pulse to be
  transmitted and processed as a Mode 4 pulse.
 -Fixed bug that caused the bottom track velocity to be truncated
  by up to 1 mm/s if a terrain bias correction is applied.
 -Fixed bug that caused PD10 output to contain invalid results for
  depth standard deviation.
 -Fixed bug that caused PA test to hang unless trigger inputs are
  supplied when CX is set to 1.
 -Fixed bug that mangled the output from the CE command.
------------------------------------------------------------------
Version 16.20 (27NOV2001)
 - Added support for the Seabird MicroCAT CTD sensor.
 - Error Velocity Screening in water profiling is now disabled
   for all coordinate systems when WE is set to 0.
 - Fixed a potential BT accumulation bug.
 - Change the behaviour of AP & AZ slightly.  Now if no sensor
   is detected, the function outputs an error message indicating
   the lack of a pressure sensor and returns.
------------------------------------------------------------------
Version 16.21 (21MAR2002)
 -Re-enabled CL Command.  1(Default) enables sleeping between pings
  and 0 disabled sleeping.  Greatly increasing power consumption.
 -Implemented a software break.  CL must be 0.  "===" or "+++"
  are the break strings.
 -Added H, P & R to the Waves Packet data. Enabled by setting
  HD to xxx 1xx xxx, where x = 0 or 1.
 -Fixed a bug in the Waves Mode which prevented the automatic bin
  selecting routine from getting seeded with the right depth and
  thus chose the wrong bins.  This only occured when no current
  profiling (wp0) was occuring during waves acquisition.
 -Fixed a bug which caused the TF command to fail in waves mode.
  Failures range from no wake-up to un-predictable.
 -Fixed a bug in the waves mode which caused the first 2 ensembles
  to be incorrectly spaced.  After first 2, all others are spaced
  correctly in time.
------------------------------------------------------------------
Version 16.22 (09AUG2002)
- Added PD15 output mode.  This mode outputs the same data as PD0, but
  converts three bytes of binary data into four bytes all of which
  have values >= 0x40 and <= 0x7F.  This is to prevent satellites
  from interpreting data as command characters.
------------------------------------------------------------------
Version 16.23 (05FEB2003)
- Added delay to start of sleep function to prevent mangling of
```

```
  the last byte sent at 1200 baud.  (last bit was randomly set).
------------------------------------------------------------------
Version 16.24 (10-OCT-2003)
 -Modified EP and ER commands to accept up to +/- 60 degrees
  of manual tilt.
------------------------------------------------------------------
Version 16.27 (13-MAY-2005)
 - Added raw waves data buffering
 - Updated PT3 pass/fail criteria
 - Added support for 150 kHz
 - Fixed error in WI command
 - Changed to clear BITResult word in Waves mode between ensembles
 - PD18 added (same as PD16, but has leading '$' for NMEA compliance)
 - Updated limit on waves pings per burst (HP) to 8400
 - Fixed problem with BM7 dropouts for depth > 18 meters
 - Fixed error in output of PD4
 - Added clock jump detection and recovery, with events recorded
   in fault log and PD0 Error Status Word.
 - Changed to clear Error Status Word after each output.
 - Changed default for CN to disable NVRAM dump in PD0
 - Fixed averaging of RSSI & correlations in WM5 when bottom in range.
 - Fixed recorder test so it won't talk to card if not present
 - Added fields to fixed leader for compatibility with other products.
 - Removed extra delay in Master mode ensemble timing
 - Fixed bottom track output for LADCP mode
 - Added LA & LC commands (similar to WA, WC) for LADCP mode
 - Fixed error in mode output when using LADCP mode
 - Re-enabled the BD command for SC users
 - Fixed correlation & RSSI threshold outputs for BM7
 - Fixed truncation errors in RSSI bottom location
 - Fixed correlation normalization error in WM12
 - Added PD15 for NDBC satellite link compatibility
 - Added CFxx2xx option to output a newline after each ensemble
 - Disabled output of binary data when using PD8 recording data
 - Added support for hi-resolution water modes to waves operation
 - Added ability to read in NMEA $HDT string
 - Fixed error where sleep cut off output at low baud rates
 - Fixed problem where optional features were lost on a firmware upgrade
 - Added PD16 NMEA-style output, but without leading '$' for compatibility
   with Seabird acoustic modems.
 - Expanded input limits for EP and ER commands.
 - Added ability to record Waves data while outputting serial ensemble data
 - Added support for a 30 degree transducer
 - Added capability to request most recent ensemble with CE1 command
 - Removed PT5 from list of tests run by PA command
 - Modified PT5 test to remove any pass/fail indication; this test has
   been deemed invalid for assessing go/no-go status, but still provides
   useful information for engineers.
 - Fixed spurious failure reports in PT3 test
 - Changed test limits for PT6 test for 150KHz (Bug 2204).
 - Added ESW and fault logging of alarm verification error.
 - Made polled mode and s/w break mutually exclusive so that polled mode
   commands will be read consistently.
 - Changed output in PD15 to indicate PD0 in the variable leader.
 - Limited ambiguity velocity to 330 when WB = 1.
------------------------------------------------------------------
Version 16.28 (07-OCT-2005)
 - HotFix Release:
 - Fixed uninitialized variable in output buffering.
 - Defined Clock Reset flag for Error Status Word.
 - Fixed error in LADCP NB mode.
 - Fixed error in sleep timing logic.
 - Added Error status flags to watch for NEMO buffer
   overflow and serial output timeout conditions.
------------------------------------------------------------------
Version 16.30 (02-NOV-2007)
 - Modified Fixed leader to match Navigator (added Instrument serial number
   and Beam angle fields.
```

- Converted the LADCP Mode to Water Mode 15, so that the feature set does not have to be changed when shifting into or out of LADCP Mode.
- The BG & BH commands have been removed.
- Implemented single-tilt compass calibration.
- Implemented bin mapping for Ship coordinates.
- Modified to output data in compass coordinates.
- Corrected behavior of the RI command in Waves mode.
- Corrected problem with Beam angle reverting to 20 degrees on cold boot.
- Corrected clock drift WM = 12 and BP > 1
- Corrected acquisition of Speed-of-Sound when in Waves mode.
- Corrected handling of negative EB values in PD3.
- Corrected saving of RS-422 parameters.
- Removed the WX command.
- Changed the Company name in the banner.
- Added code to clear the First-Ping-Time once it has been used.
- Modified code to assure that the correct frequency is used if the one-wire devices cannot be read.
- Corrected the behavior of the polled mode.
- EZ will no longer allow Non-zero values for salinity data source.
- PD8 data is now output in compass coordinates rather than cartesian coordinates.
- Corrected Mode 12 velocity calculations.
- Correcte bitmaps in First packet leader (Waves mode).
- LADCP (WM-15) now accepts both 'L' and 'W' commands.
- Made corrections to prevent <break> from being recognized on the RS-485 lines when it is not valid (i.e. lines in use for RDS3 triggering).
- Negative numbers no longer displayed in Recorder Directory.

NOTES

NOTES

Monitor / Sentinel Setup Card

1. Documentation

Thank you for purchasing a Teledyne RD Instruments (TRDI) Monitor or Sentinel Acoustic Doppler Current Profiler (ADCP). All documentation is being provided to you on CD in a fully searchable, printable, electronic format. This way, information is always available, whether you are at the office or in the field, and the electronic format is an environmentally friendly way to provide a large set of technical manuals. The documentation for each software program is located on the software program's CD.

To purchase a printed copy of the system documentation (includes the WorkHorse Technical Manual, User's Guide, and software guides), contact our Customer Service department at rdifs@teledyne.com or call (858)-842-2600 and order the WorkHorse Technical Manual kit.

2. Unpacking and Inventory

When unpacking, use care to prevent physical damage to the transducer faces and connector. Use the protective cap and a soft pad to protect the transducer. When handling any electronics modules, follow electrostatic discharge (ESD) prevention measures.

Use the following figure to ensure you have all of the Workhorse equipment.

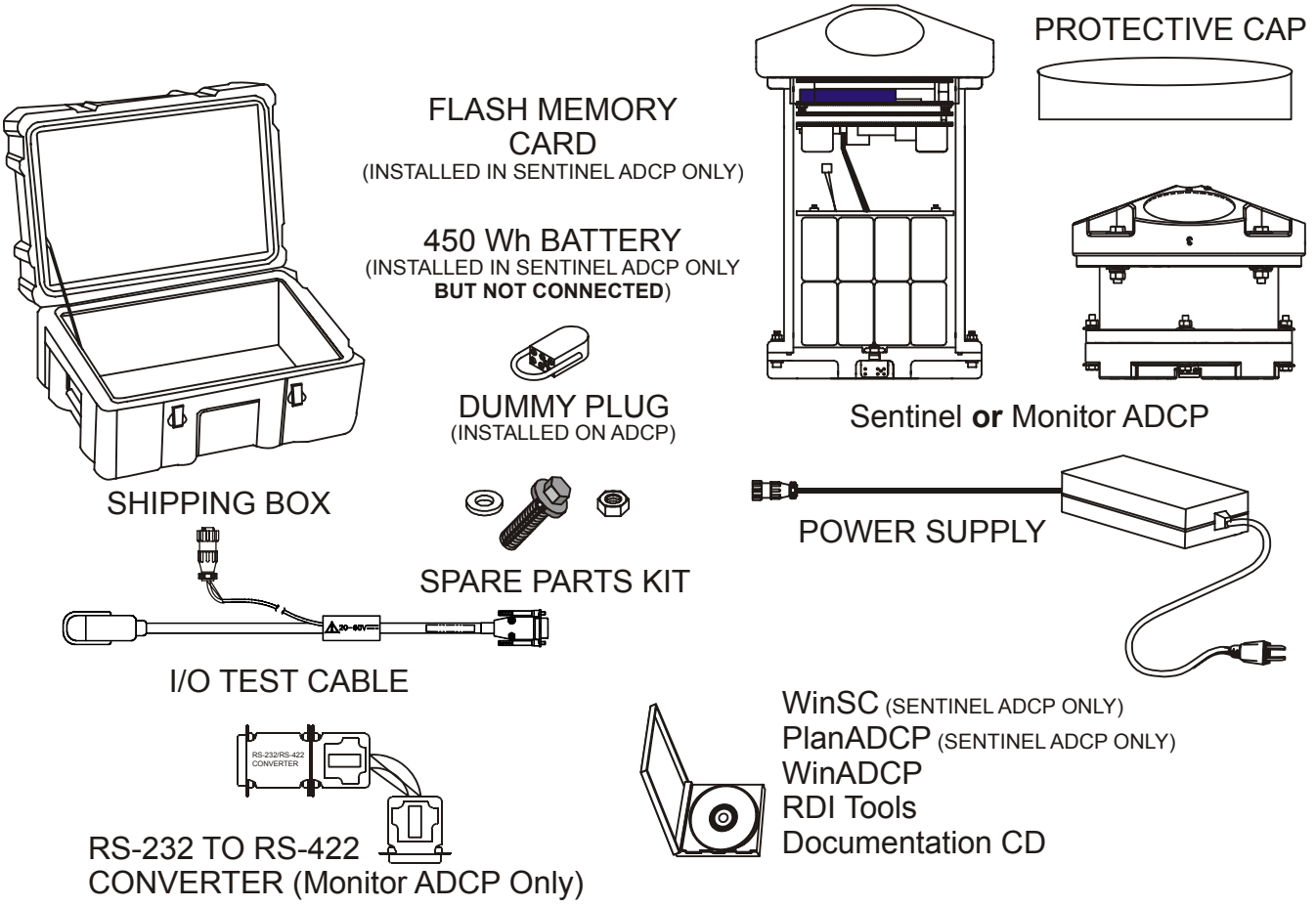

Figure 1. Workhorse Inventory

3. Set Up the Workhorse

Use this figure to connect the Workhorse to a computer for a bench test. Refer to the Workhorse User's Guide for more details on system interconnections.

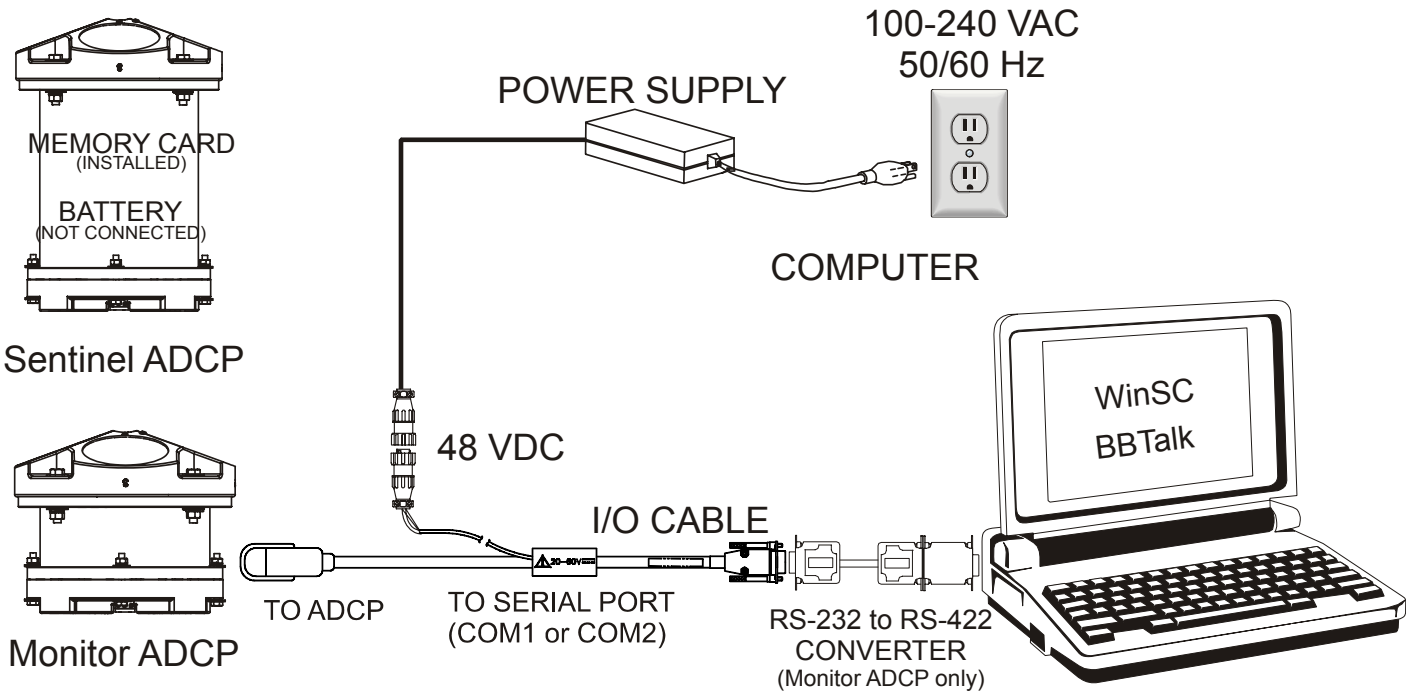

Figure 2. Workhorse Connections

4. System Requirements

TRDI software requires the following:

- Windows XP® or Windows 2000®
- Pentium III 600 MHz class PC (higher recommended)
- 64 megabytes of RAM (128 MB RAM recommended)
- 50 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended)
- One Serial Port (two or more High Speed UART Serial Port recommended)
- Minimum display resolution of 1024 x 768, 256 color (higher recommended)
- CD-ROM Drive
- Mouse or other pointing device

5. Install the Software

To install the software, do the following.

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps "b" through "d."

b. Click the **Start** button, and then click **Run**.

c. Type **<drive>:launch**. For example, if your CD-ROM drive is drive D, type **d:launch**.

d. Follow the browser instructions on your screen. Once, installed, you will have a shortcut added to your Windows® **Start** menu.

6. Test the Workhorse

BBTalk (included on the RDI Tools CD) will establish communications with the Workhorse and run the System Test to make sure the Workhorse is functioning properly. If you have questions about *BBTalk* operation, see the *RDI Tools* User's Guide.

a. Connect the Workhorse as shown in Figure 2. Place the Workhorse in a bucket of water (enough water to cover the transducer head). If the Workhorse is not placed in water, some of the tests will fail (but not harm the ADCP).

b. Start the *BBTalk* program.

c. Press **<F2>** and run the script file *TestWH.rds*. The results of the tests will be printed to the screen and saved to the log file *WH_RSLTS.txt*.

7. Workhorse Care

This section contains a list of items you should be aware of every time you handle, use, or deploy your Workhorse ADCP. *Please refer to this list often*.

General Handling Guidelines

- Never set the transducer on a hard or rough surface. **The urethane faces may be damaged.**
- Always remove the retaining strap on the end-cap underwater-connect cable and dummy plug when disconnecting them. **Failure to do so will break the retainer strap.**
- Do not apply any upward force on the end-cap connector as the I/O cable is being disconnected. **Stressing the end-cap connector may cause the ADCP to flood.** Read the Technical Manual for details on disconnecting the I/O cable.
- Do not expose the transducer faces to prolonged sunlight. **The urethane faces may develop cracks.** Cover the transducer faces on the ADCP if it will be exposed to sunlight.
- Do not expose the I/O connector to prolonged sunlight. **The plastic may become brittle.** Cover the connector on the ADCP if it will be exposed to sunlight.
- Do not store the ADCP in temperatures over 60 degrees C. **The urethane faces may be damaged.**
- Store Workhorse Sentinel batteries in a **cool dry location** (0 to 21 degrees C). If the batteries are installed in the ADCP (Sentinel only), do not store the ADCP in temperatures over 21 degrees C.
- Do not store batteries inside the Workhorse (Sentinel only) for extended periods. **The batteries may leak.**
- Use batteries within one year. **Batteries stored for more than 12 months should NEVER be used!**
- Vent the system before opening by loosening the end-cap. **If the ADCP flooded with batteries installed, there may be gas under pressure inside the housing.**
- Do not scratch or damage the O-ring surfaces or grooves. **If scratches or damage exists, they may provide a leakage path and cause the ADCP to flood.** Do not risk a deployment with damaged O-ring surfaces.
- Do not lift or support an ADCP by the external I/O cable. **The connector or cable will break.**

Assembly Guidelines

- Read the Workhorse Technical Manual for details on re-assembly. Make sure the housing assembly O-rings stay in their groove when you re-assemble the unit. Tighten the hardware as specified. **Loose, missing, stripped hardware, or damaged O-rings can cause the ADCP transducer to flood.**
- Place a light amount of silicone lubricant on the end-cap connector pins (rubber portion only). **This will make it easier to connect or remove the I/O cable and dummy plug.**
- Do not connect or disconnect the I/O cable with power applied. An exception to this is the optional external battery case. The external battery case connector is always "hot" when batteries are installed. When you connect the cable with power applied, you may see a small spark. **The connector pins may become pitted and worn.**

Deployment Guidelines

- Read the Workhorse User's Guide and the Software User's Guides. **These guides have tutorials to help you learn how to use the ADCP.**
- Workhorse Sentinel batteries are shipped inside the ADCP but not connected. **Connect the battery and seal the unit before deployment.**
- Align the compass whenever the battery pack or flash memory card is replaced, or when any ferrous metals are relocated inside or around the Workhorse Sentinel housing. **Ferro-magnetic materials affect the compass.**

NOTE. When the batteries are changed the compass must be calibrated with the AF command (see the WorkHorse Commands and Output Data Format Guide).

- The AC power adapter is not designed to withstand water. **Use caution when using on decks in wet conditions.**
- Avoid using ferro-magnetic materials in the mounting fixtures or near the Workhorse. **Ferro-magnetic materials affect the compass.**

8. How to Contact Teledyne RD Instruments

If you have technical issues or questions involving a specific application or deployment with your instrument, contact our Field Service group:

Teledyne RD Instruments

14020 Stowe Drive
Poway, California 92064

Phone +1 (858) 842-2600

FAX +1 (858) 842-2822

Sales – rdisales@teledyne.com

Field Service – rdifs@teledyne.com

Teledyne RD Instruments Europe

2A Les Nertieres
5 Avenue Hector Pintus
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Sales – rdie@teledyne.com

Field Service – rdiefs@teledyne.com

Customer Service Administration – rdicsadmin@teledyne.com
Web: http://www.rdinstruments.com
24/7 Technical Support +1 (858) 842-2700

WorkHorse Monitor / Sentinel User's Guide

P/N 957-6228-00 (November 2007)

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Monitor and Sentinel User's Guide

Introduction

Thank you for purchasing the Teledyne RD Instruments (TRDI) WorkHorse Monitor/Sentinel Acoustic Doppler Current Profiler (ADCP). This User's Guide will lead you through the steps required for a successful deployment. Please read the entire guide, and then follow the instructions in the order they are presented. Additional information can be found in the WorkHorse Technical Manual that is supplied on CD-ROM.

NOTE. To purchase a printed copy of the WorkHorse documentation (includes the WorkHorse Technical Manual and software guides), contact our Customer Service department at rdifs@teledyne.com or call (858) 842-2600 and order the WorkHorse Manual kit.

Technical Support

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24/7 Technical Support +1 (858) 842-2700

Overview

The first step is to become familiar with the Monitor/Sentinel ADCP. Read the short descriptions of the hardware and software that comes with the WorkHorse.

This Section Covers:

- Hardware Overview
- Battery Packs and Power Overview
- Serial Communication Overview
- Deployment Overview
- Software Overview
- Installing the Software

Hardware Overview

The WorkHorse Sentinel ADCP system consists of an ADCP, cables, battery pack, flash memory card, and software. The WorkHorse Sentinel can also be used for direct-reading current profile operation. The ADCP requires the addition of a Windows® compatible computer to configure the ADCP and replay collected data.

The WorkHorse Monitor system consists of an ADCP, cables, and software. The Monitor does not include the internal battery or flash memory and therefore uses a shorter housing. The Sentinel and Monitor use the same electronics.

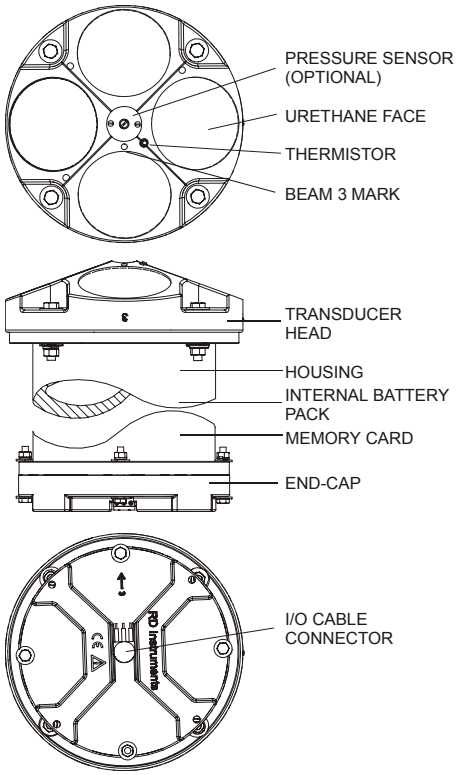


Figure 1. WorkHorse Sentinel Exploded View

The transducer assembly contains the transducer ceramics and electronics. Standard acoustic frequencies are 600 and 1200 kHz. See the outline drawings in the WorkHorse Technical Manual for dimensions and weights.

I/O Cable Connector – Input/Output (I/O) cable connects the WorkHorse ADCP to the computer.

Beam-3 Mark – The Beam-3 mark shows the location of Beam-3 (Forward).

Urethane Face – The urethane face covers the transducer ceramics. Never set the transducer on a hard surface. The urethane face may be damaged.

Housing – The WorkHorse housing allows deployment depths to 200 meters.

Thermistor – The Thermistor measures the water temperature.

Pressure Sensor – The optional pressure sensor measures water pressure (depth).

Transducer Head – The WorkHorse electronics and transducer ceramics are mounted to the transducer head. The numbers embossed on the edge of the transducer indicates the beam number. When assembling the unit, match the transducer beam number with the Beam 3 mark on the end-cap.

End-Cap – The end-cap holds the I/O cable connector. When assembling the unit, match the Beam 3 mark on the end-cap with beam 3 number on the transducer.

Internal Battery Pack – WorkHorse Sentinel ADCPs use an internal battery pack to provide power to the ADCP.

Flash Memory Card – WorkHorse Sentinel ADCPs come standard with one memory card. Two PCMCIA memory cards slots are available, with the total memory capacity not to exceed 1GB.

Battery Packs and Power Overview

WorkHorse Monitor/Sentinel ADCPs require +20 to 50 VDC to operate. The standard AC Adapter runs on any standard AC power and supplies +48 VDC to run the WorkHorse when the batteries are not connected. The WorkHorse Sentinel's internal battery supplies +42 VDC.

NOTE. The AC Adapter input voltage is sufficient to override the internal battery voltage (i.e. the ADCP will draw all power from the AC adapter even if the battery is installed and connected). Always use the AC adapter when testing the ADCP to conserve the battery power.

Keep in mind the following about Sentinel battery packs:

- TRDI specifies its battery packs to have 450 Watt-hours (Wh) of usable energy at 0°C.
- A Standard WorkHorse battery packs hold 28 'D-cell' alkaline batteries with a voltage, when new, of approximately 42 VDC.
- When the capacity of a battery pack is 50% used, the voltage (measured across the battery connector under no-load conditions) falls to approximately 32 to 35 volts. However, keep in mind that this voltage is not an accurate predictor of remaining capacity.

- Transmitted power increases or decreases depending on the input voltage (within the voltage range of 20 to 50 VDC). A fresh battery provides +42 VDC. Batteries spend most of their life at a nominal voltage of +33 VDC.

NOTE. The transmitted power is decreased one DB if the input voltage drops from 42 VDC to 33 VDC. For a 600 kHz WorkHorse ADCP, each one DB drop will result in a decrease in range of one default depth cell.

- Batteries should be replaced when the voltage falls below 30 VDC (measured across the battery connector under no-load conditions).
- Battery packs differ from one to another.
- Store batteries in a cool dry location (0 to 21 degrees C).
- Do not store batteries inside the ADCP for extended periods. The batteries may leak.
- Use batteries within one year (shelf life).

NOTE. Battery replacement induces both single and double cycle compass errors. The compass accuracy should be verified after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an optional external battery pack. The optional external battery housing holds two batteries, and can easily be replaced on-site. If the optional external battery is placed a minimum of 30 cm away from the ADCP, no compass calibration will be required.

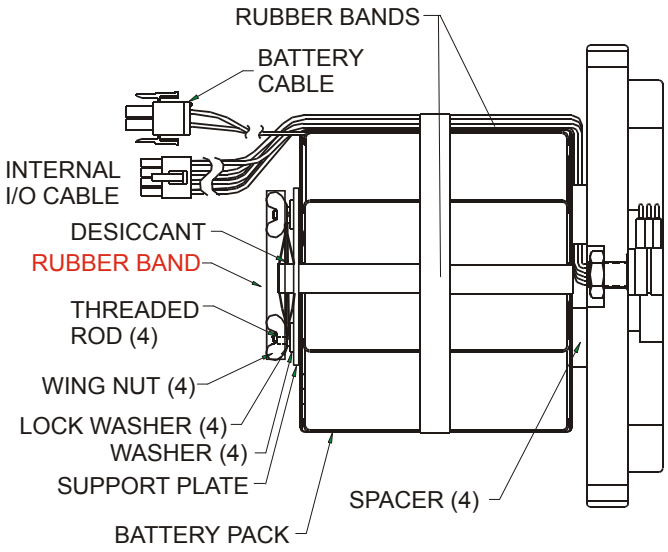


Figure 2. WorkHorse Sentinel Battery Pack

Optional External Battery Pack

The optional External Battery Pack holds two 450 Watt-hours (Wh) batteries. To avoid affecting the compass, place the external battery case at least 30-cm away from the WorkHorse ADCP.

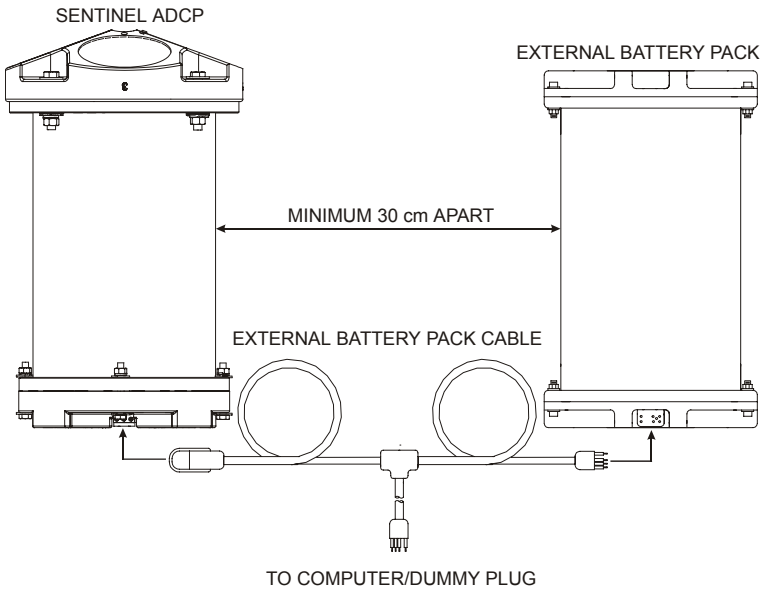


Figure 3. External Battery Pack Connection

NOTE. The optional external battery pack can be used with both the WorkHorse Monitor and Sentinel model ADCPs.

Flash Memory Card

WorkHorse Sentinel ADCPs come standard with one memory card. Two PCMCIA memory cards slots are available, with the total memory capacity not to exceed 2GB. Memory cards are not included with the Monitor ADCP. The PC Card recorder is located on the Digital Signal Processor (DSP) board inside the Workhorse's electronics. To recover data, the card can be removed and used in a personal computer (PC), or left in the Workhorse, and accessed by using *WinSC* (see the WinSC and PlanADCP User's Guide).

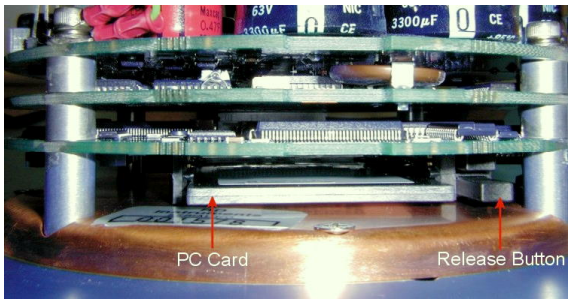


Figure 4. Memory Card Overview

Serial Communication Overview

The standard communications settings for the WorkHorse Monitor/Sentinel is RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. Self-contained applications receive no benefit from setting a faster baud rate.

You can set the WorkHorse for baud rates other than 9600 baud using the CB command (see the WorkHorse Technical Manual). If you make the new baud rates permanent with the CK command, *WinSC* and *BBTalk* will search for the correct settings if you use the **Auto Detect** function, which searches for the WorkHorse's current serial port and baud rate (see "Connecting to the WorkHorse," page 22). If you tell the programs these settings, you will save time required for searching. Both *WinSC* and *BBTalk* will use the last communication setting for future use.

Change Communication Setting. Changing a switch setting on the PIO board will change the communication setting between RS-232 and RS-422. The switch is in plain view on the top circuit board, near the cable connectors. Its settings are plainly marked on the board. If the serial protocol is set for RS-422 and your computer expects RS-232, you will need an RS-232 to RS-422 adapter between the ADCP cable and your computer. This user's guide assumes that you use RS-232. There is no reason to use RS-422 for Self-Contained operations.

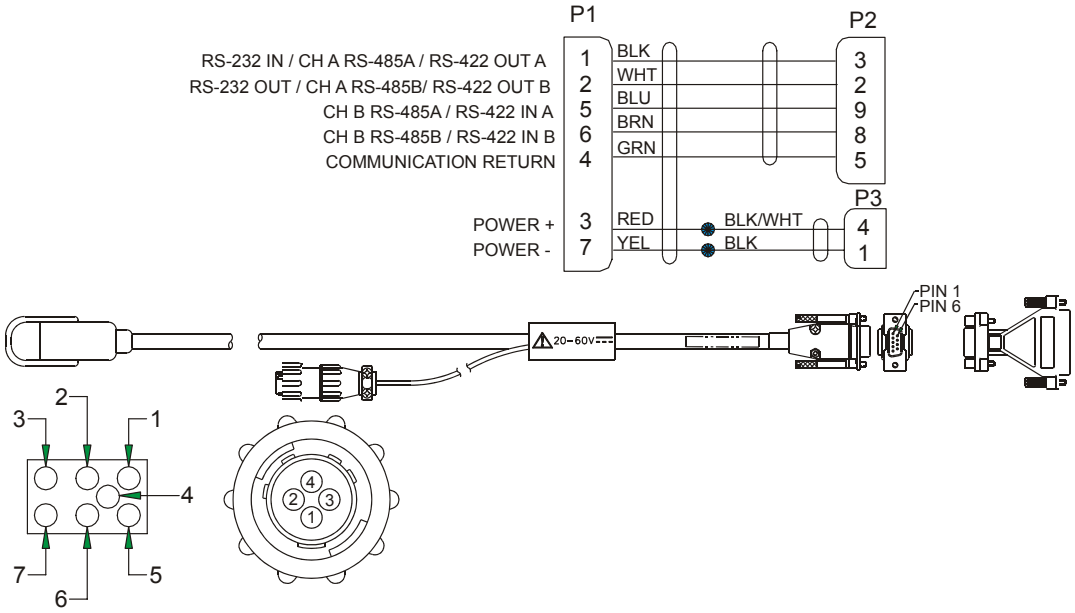


Figure 5. I/O Cable Wiring Diagram

Deployment Overview

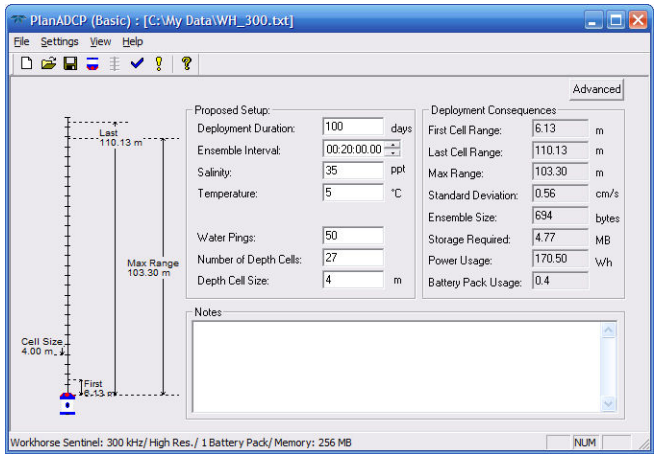
WorkHorse Sentinel deployments are most often Self-Contained but can be Real-Time. Typically, deployments are considered to be Self-Contained when the WorkHorse ADCP is remotely deployed and powered using internal batteries. In this configuration, no external connections to the WorkHorse are made during the deployment. However, the WorkHorse can be connected to external power. This power can be provide either by an external battery case or from shore. This type of deployment is still considered Self-Contained, but this guide may not consider all of the possibilities of this application.

WinSC is the software package for self-contained WorkHorse setup, data collection, and data review. *PlanADCP* (part of *WinSC*) lets you enter known or "best-guess" values for the various WorkHorse profiling parameters and shows predictions of expected results. The WorkHorse Sentinel can be used for several-month autonomous current profile deployments from temporary or permanent mountings in the ocean, near-shore, harbors, and lakes.

Real-Time use refers to the fact you are viewing the data as the WorkHorse ADCP collects it via a personal computer. This data is also stored on the computer to allow for data playback and processing at a later time. Use *PlanADCP* to create the command file to set the values for the various WorkHorse profiling parameters and *WinADCP* to view the data.

Software Overview

You will need several software programs to test and collect data with the WorkHorse ADCP.

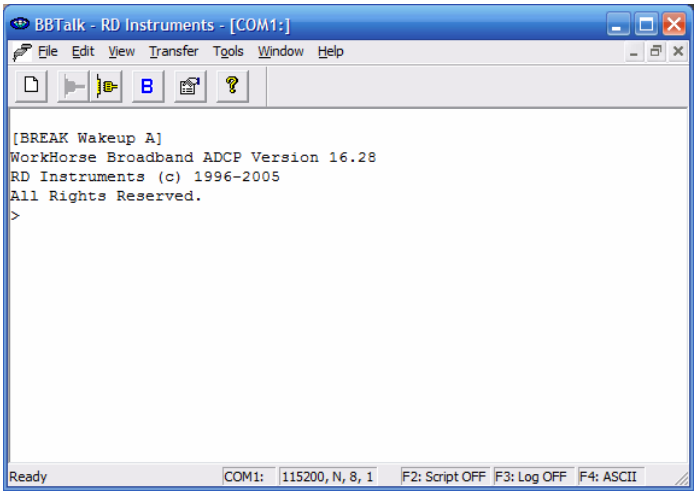


WinSC & PlanADCP

WinSC and *PlanADCP* are designed to set up a Sentinel WorkHorse ADCP for collecting data. Specifically, *PlanADCP* will set the WorkHorse commands correctly.

The *PlanADCP* screen shows you an overview of your setup and the resulting consequences of your deployment.

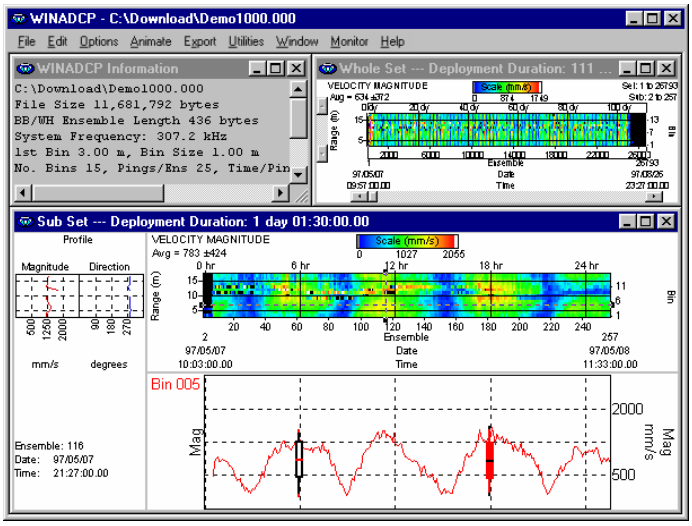
For more information see the *WinSC* and *PlanADCP* User's Guide and "Collecting Self-Contained Data," page 32 or "Collecting Real-Time Data," page 43.



BBTalk

BBTalk is a terminal emulator that allows your computer to communicate with the WorkHorse via RS422 or RS232.

This guide does not go into detail about the operation of *BBTalk*. For more information see the RDI Tools User's Guide.



WinADCP Main Screen

WinADCP gives users a visual display of the entire set of data. You can zoom in on a portion of the data for closer analysis and export data to text or MatLab files.

Use *WinADCP* to view color contour and time-series plots of data collected with an WorkHorse Monitor in real-time or playback data collected with an WorkHorse Sentinel.

For detailed information on how to use *WinADCP*, see the WinADCP User's Guide.

Installing the Software

You will be installing several software packages. These will be required for testing and deployments.

The WorkHorse software requires the following:

- Windows XP®, Windows 2000®, or Windows 98®
- Pentium class PC 233 MHz (350 MHz or higher recommended)
- 32 megabytes of RAM (64 MB RAM recommended)
- 6 MB Free Disk Space (20 MB recommended)
- One Serial Port (two High Speed UART Serial Ports recommended)
- Minimum display resolution of 800 x 600, 256 color (1024 x 768 recommended)

Software Installation

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps "b" through "d."

b. On the Windows task bar, click the **Start** button, and then click **Run**.

c. Type <drive>:launch. For example, if your CD-ROM drive is drive D, type d:launch.

d. Follow the browser instructions on your screen

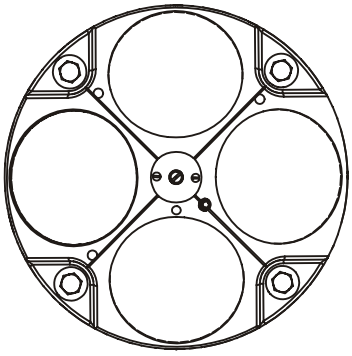
WorkHorse Preparation

Proper WorkHorse ADCP preparation is critical for a successful deployment. In this section we will prepare the WorkHorse Monitor/Sentinel ADCP for deployment.

Deployment Checklist

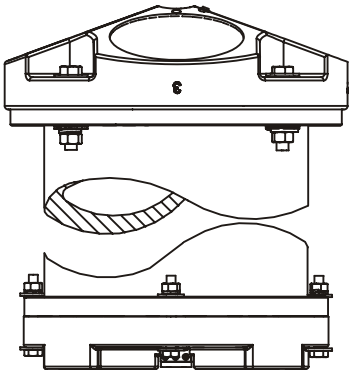
- **Visually inspect the WorkHorse**
  - Check the I/O Cable and connector pins for damage
  - Check the housing condition for damage
  - Check the transducer faces are clean and free from defects
- **Seal the WorkHorse for deployment**
  - Install and connect the battery (WorkHorse Sentinel ADCP only)
  - Check Recorder PC card is installed (WorkHorse Sentinel ADCP only)
  - Use fresh desiccant (2 bags) inside WorkHorse ADCP
  - Install new o-rings; use silicone lubricant
  - Check all mounting hardware is installed
- **Bench Tests**
  - Test the WorkHorse using *BBTalk*
  - Verify the compass alignment using *BBTalk*; if necessary, re-calibrate
  - Check the recorder status using *BBTalk* (WorkHorse Sentinel ADCP only)
- **Final Preparation for Deployment**
  - Are biofouling precautions needed?
  - Clean the optional pressure sensor port copper screw
  - Zero the pressure sensor (optional) at deployment site with AZ-command

VISUALLY INSPECT THE ADCP



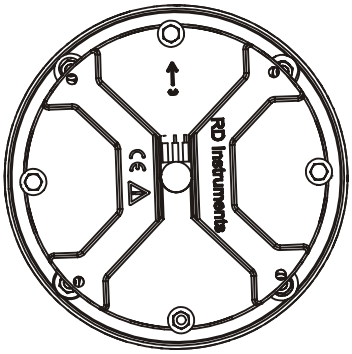
URETHANE TRANSDUCER FACES
REMOVE BARNACLES AND
CHECK FOR CRACKS

TRANSDUCER HEAD
CHECK O-RINGS
AND MOUNTING
HARDWARE ARE
INSTALLED



HOUSING
CHECK FOR
CRACKS

ELECTRONICS AND
BATTERY PACKS
CHECK MEMORY CARD
AND BATTERIES ARE
INSTALLED



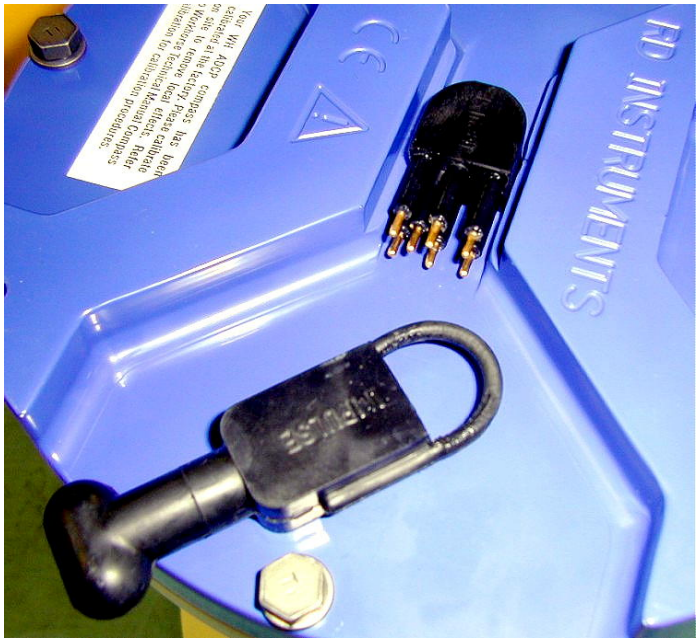
END-CAP
CHECK O-RINGS AND
MOUNTING HARDWARE
ARE INSTALLED

I/O CABLE CONNECTOR
INSTALL DUMMY PLUG

Figure 6. Visual Inspection Checklist

Visual Inspection

Before connecting the WorkHorse ADCP, make a quick visual inspection of the components to make sure nothing is damaged.

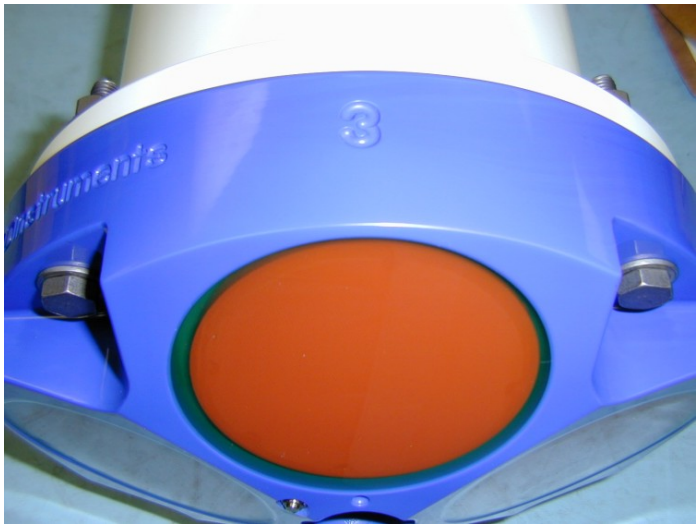


Check the I/O Cable and connector pins for damage

Roll the I/O cable rubber retaining strap up so that it does not hinder plug removal.

Remove the dummy plug or cable by pulling with a straight-out motion. Do not wiggle the connector up; this can damage the connector pins. A slight side-to-side wiggle as you are pulling on the cable is OK.

Inspect the pins for damage. Make sure that they are straight and that there is no corrosion on the metal surfaces.



Check the WorkHorse for damage

Inspect the WorkHorse ADCP for damage. There should be no cracks or peeling surfaces.

Check the transducer faces are clean and free from defects

Inspect the WorkHorse ADCP for damage. There should be no cracks or peeling surfaces.

Seal the WorkHorse for Deployment

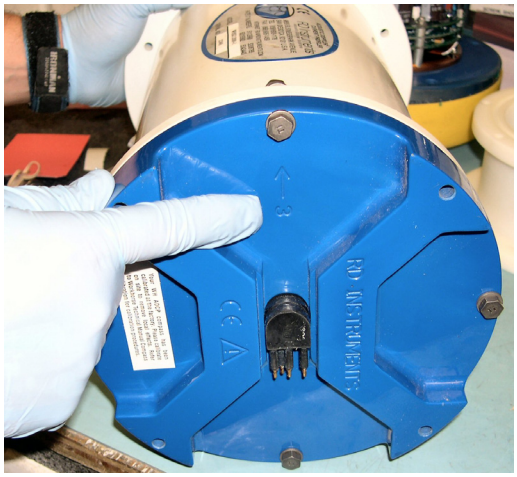
Before you put the WorkHorse ADCP into the water, you must prepare it for deployment.

- Install and connect the battery (WorkHorse Sentinel ADCP only)
- Replace the desiccant inside the WorkHorse
- Install new o-rings; use silicone lubricant
- Check all mounting hardware is installed

NOTE. Only the end-cap removal instructions are included in this Quick Start Guide. If you need access to the WorkHorse electronics, the transducer head must be removed. Please refer to the WorkHorse Technical Manual for instructions.

Install and Connect the Sentinel Battery

To install the WorkHorse Sentinel battery pack, do the following steps. Read the WorkHorse Technical Manual for details.

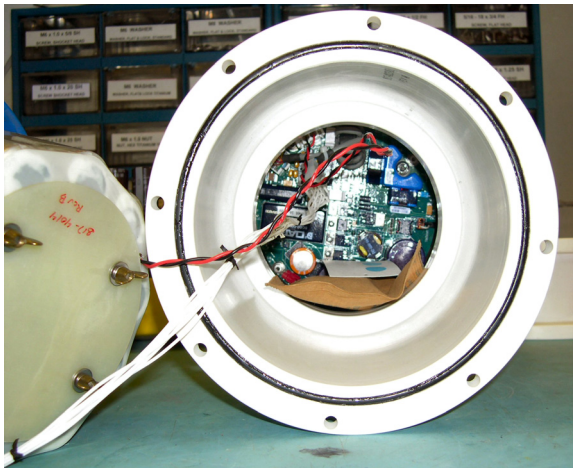


Place the WorkHorse Sentinel ADCP on its side.

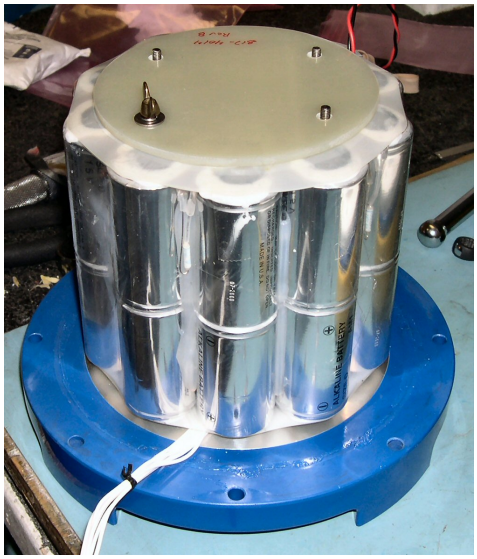
Make note of the location of Beam 3. The Beam 3 mark on the end cap should be aligned with the label on the housing and the Beam 3 mark on the transducer.

Loosen and remove the four M6 bolts holding the end-cap to the housing.

Gently slide the end-cap and battery assembly out of the housing. The two cables are long enough to allow the assembly to be placed next to the housing (see next photo).



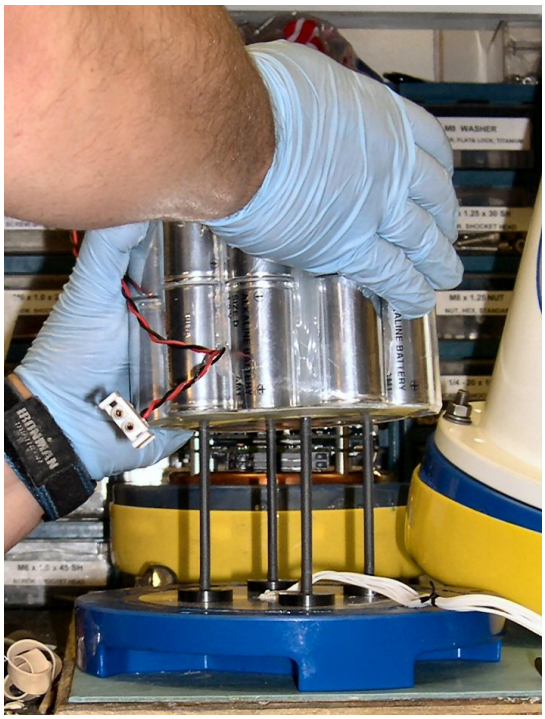
Disconnect the battery cable and internal I/O cable going to the common mode choke on the top PC Board.



Remove the four wing nuts, lock washers, and washers holding the battery pack onto the posts.

Remove the support plate.

Slide out the used battery pack.



Slide a new battery pack onto the four posts. Make sure the I/O cable is not pinched by the battery pack.

Use the large rubber bands (supplied with each new pack) to hold the cables in place.

Test the battery pack voltage by measuring across the battery connector under no-load conditions. The voltage should be +42 VDC for a new battery pack.

Position the support plate over the four posts.

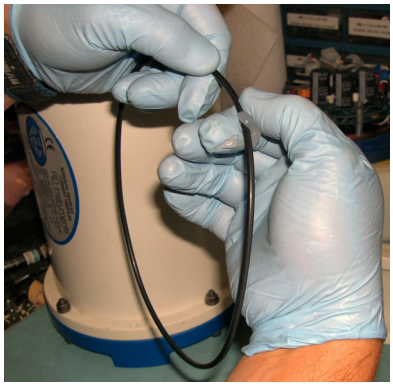
Place a flat washer, lock washer, and wing nut on each of the four posts. Tighten the wing nuts firmly to hold the battery in place.

Place a battery pack rubber band (two spare rubber bands are provided with each new battery) around all four wing nuts. This will prevent the wing nuts from backing off the post.

CAUTION. The WorkHorse Sentinel battery pack is held in place by four sets of washers, lock washers, and wing nuts. If the wing nuts are not tight, the assembly of washers and wing nut can become loose and eventually fall onto the PIO board. **This has caused the PIO board to short out.** Place a rubber band around the wing nuts to help hold them in place.

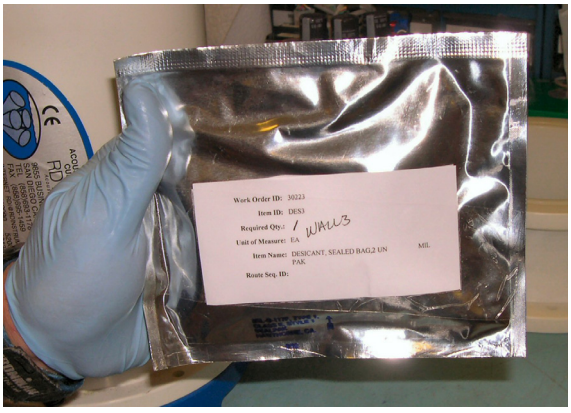
Clean the O-ring groove. Be sure the groove is free of foreign matter, scratches, indentations, or pitting. Use lint free wipes or a wood scrapper to clean the groove.

Never use Q-tips to clean the O-ring groove; loose fibers or lint can provide a leakage path.



Place a small amount of silicone lube on the O-ring and spread it over the entire O-ring surface. The O-ring should appear “shiny”. Wipe off any excess lube.

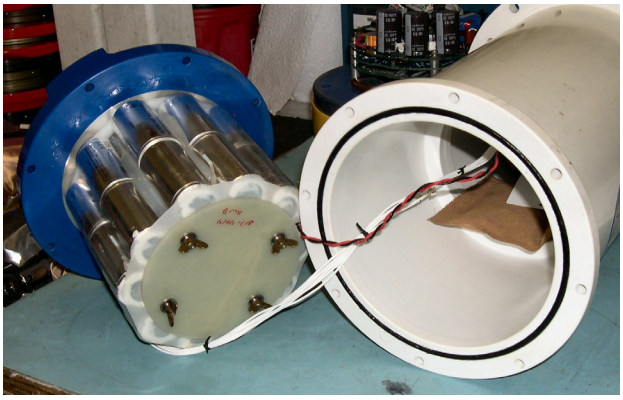
Place the O-ring in the O-ring groove on the housing.



Place a new desiccant pack and moisture indicator into the housing. Desiccant bags are used to dehumidify the housing interior.

Remove the new desiccant bags from the airtight aluminum bag.

Remove the old desiccant bags and install two new ones. Place the desiccant bags under the rubber bands on the battery pack or place on top of the PC boards.



Connect the battery and internal I/O cable going to the common mode choke.

Slide the end-cap onto the housing making sure that the beam 3 mark is aligned with the label on the housing and the beam 3 mark on the transducer head.

Make sure no wires become pinched or that the O-ring falls out of the groove.

It may be easier to tip the WorkHorse on the transducer head when connecting the end-cap to the housing. Make sure to protect the transducer faces and prevent the WorkHorse from tipping over.

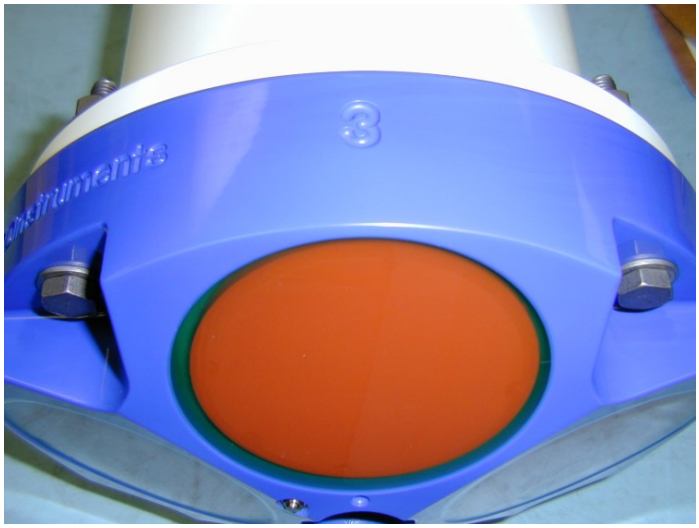
Install all four sets of hardware until “finger-tight.”

Tighten the bolts in small increments in a “cross” pattern until the split washer flattens out, and then tighten each bolt ¼ turn more to compress the face seal O-ring evenly.

Tighten the bolts to the recommended torque value of 5.6 Newton-meters (50 pound-inches).

Check all Mounting Hardware is Installed

If the housing is not properly sealed prior to deployment, the WorkHorse ADCP will be destroyed.



Transducer Head to Housing Seal

Visually inspect the mating surfaces of the housing to transducer head to ensure that there are no obstructions. The faces should be parallel to one another and there should be no gaps. Check to ensure that the titanium fasteners holding the housing together are tight.

The recommended torque value for the transducer head 8-mm bolts is 9.6 Newton-meters (85 pound-inches).

End-Cap to Housing Seal

Visually inspect the mating surfaces of the end-cap to housing to ensure that there are no obstructions. The faces should be parallel to one another and there should be no gaps. Check to ensure that the titanium fasteners holding the housing together are tight.

The recommended torque value for the end-cap 6-mm bolts is 5.6 Newton-meters (50 pound-inches).

CAUTION. Do not replace the titanium hardware with any other hardware. Corrosion will result.

If the WorkHorse was opened, read the WorkHorse Technical Manual – Maintenance section for details on WorkHorse re-assembly.

Bench Test

The bench-testing process ensures that the WorkHorse ADCP is working properly before you put it in the water. The bench-test procedure will involve powered tests that will verify that the WorkHorse ADCP's electronics and transducers are functioning.

This Section Covers:

- Setup the WorkHorse ADCP
- Test the WorkHorse ADCP
- Compass alignment

Setup the WorkHorse ADCP

You will now connect the WorkHorse ADCP to a power supply and a computer with the TRDI software installed.

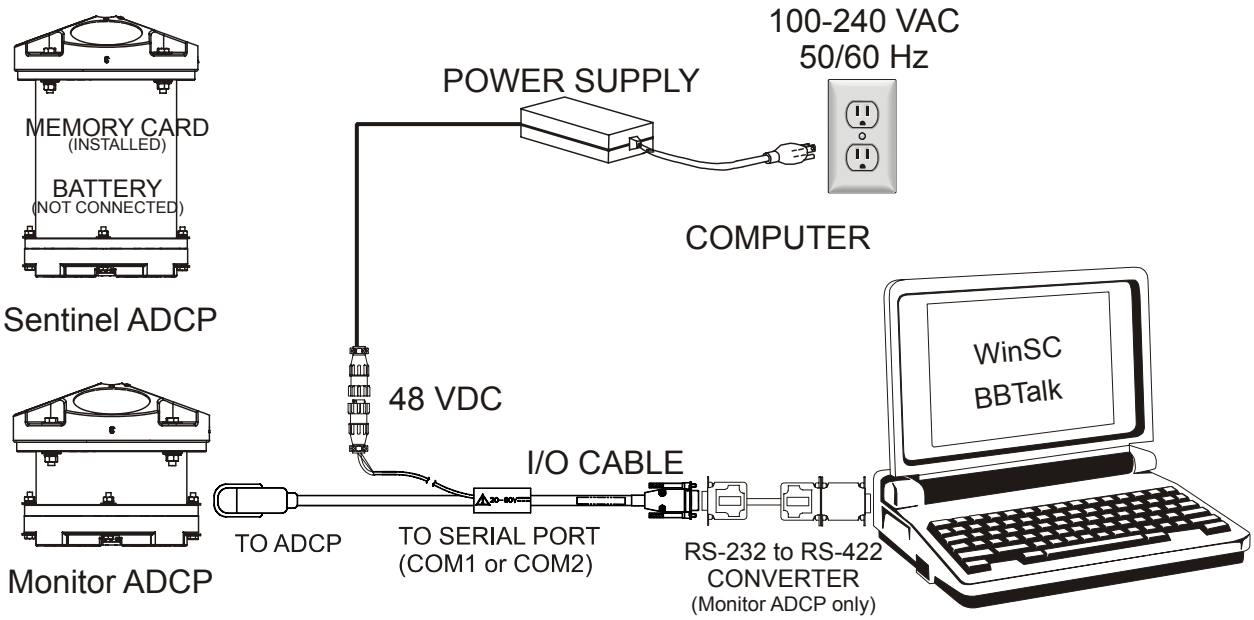


Figure 7. WorkHorse Connections

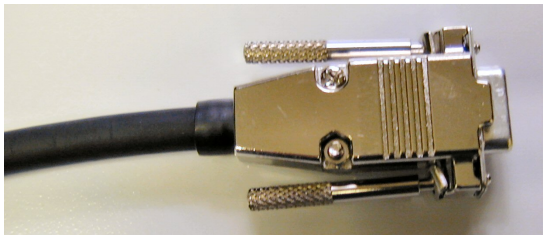
CAUTION. WorkHorse Sentinel batteries are shipped inside the WorkHorse ADCP but not connected. **Connect the battery and seal the WorkHorse ADCP before deployment.**

For testing, the battery can be disconnected to save battery power. If the battery is connected, use the AC adapter to override the battery voltage to conserve the battery (see "Battery Packs and Power Overview," page 3**).**

Connect the I/O Cable to WorkHorse

If you have not done so, connect the I/O cable to the WorkHorse ADCP. Do so by pushing straight in against the connector. Roll the retaining strap over the connector.

Place a light amount of silicone lubricant on the connector pins (rubber portion only). This will make it easier to connect or remove the I/O cable and dummy plug.



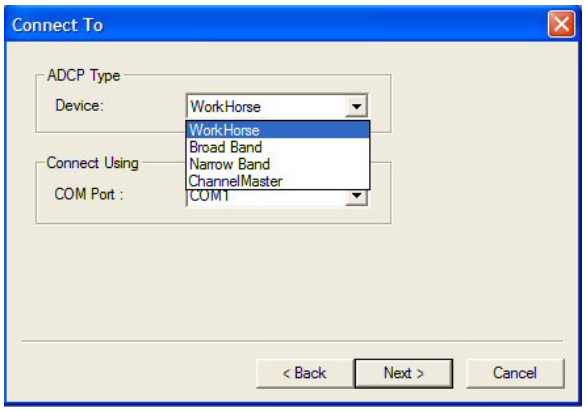
Connect the I/O Cable to Computer and Power Supply

Attach the I/O cable to your computer's communication port. The standard communications settings are RS-232, 9600-baud, no parity, 8 data bits and 1 stop bit. Self-contained applications receive no benefit from setting a faster baud rate.

Connect the power supply to the power cable.

Connecting to the WorkHorse

Use these next steps to “talk” to the WorkHorse ADCP.



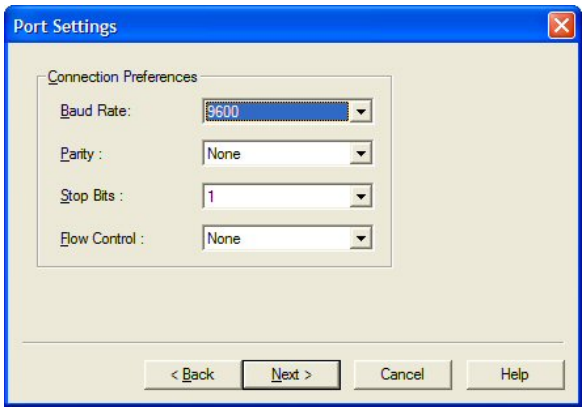
Start BBTalk

Start the *BBTalk* program (for help on using *BBTalk*, see the RDI Tools User's Guide).

On the **Connect To** screen, select **WorkHorse**.

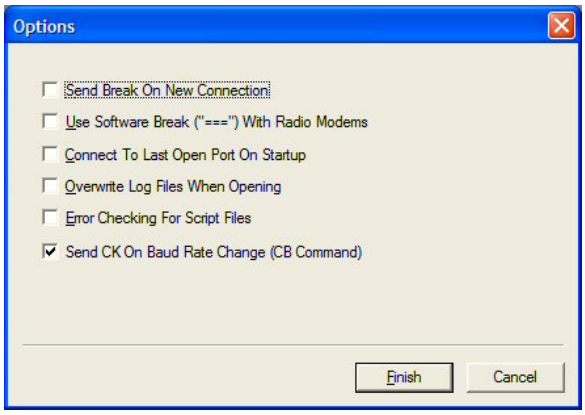
Select the COM port the WorkHorse ADCP cable is connected to.

Click **Next**.

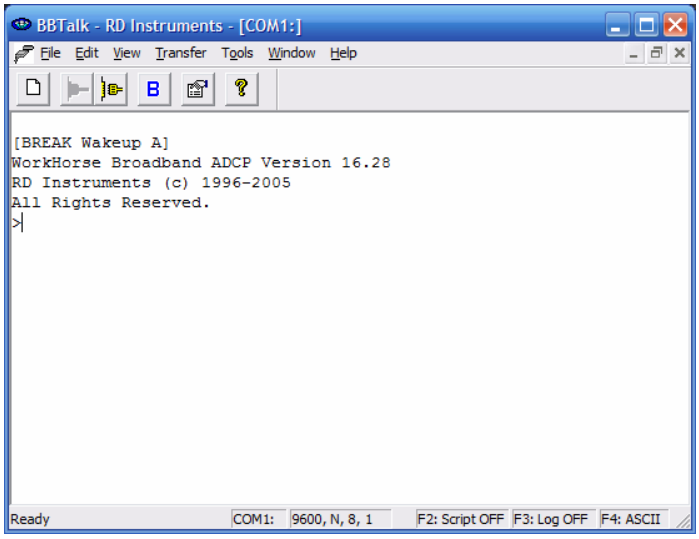


Enter the **Baud Rate**, **Parity**, **Stop Bits**, and **Flow Control**. If you are unsure of the settings, leave them at the default settings.

Click **Next**.



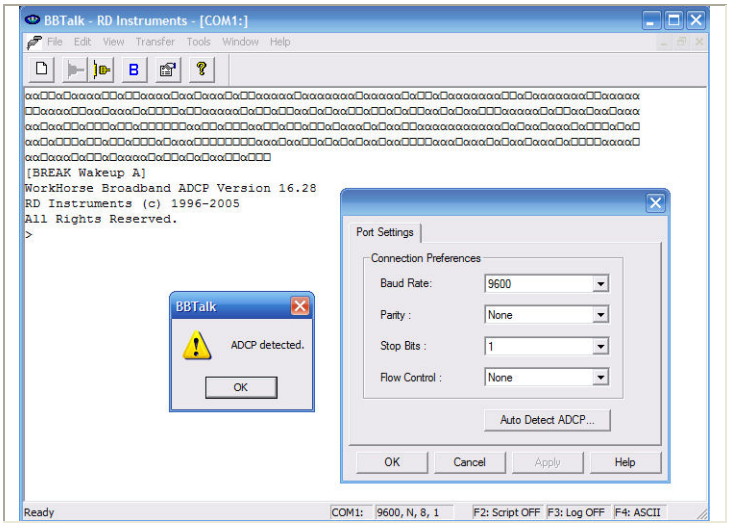
Click **Finish**.



Wakeup

On the **File** menu, click **Break** (you can also press the **End** key to send a break or press the **B** button on the Toolbar).

You should see the wakeup message appear on the log file window.



If the wakeup message is not readable, do the following.

On the **File** menu, click **Properties**. Click the **Auto Detect ADCP** button. Click **OK** when the WorkHorse is detected. Try to wakeup the WorkHorse again.

What if the WorkHorse Does Not Respond

If your WorkHorse ADCP does not respond, check the serial port, cables, AC power, and battery connection (Sentinel only). If necessary, refer to the Troubleshooting section in the WorkHorse Technical Manual.

CAUTION. WorkHorse Sentinel batteries are shipped inside the WorkHorse ADCP but not connected. **Connect the battery and seal the WorkHorse ADCP before deployment.**

Changing the Baud Rate in the ADCPs

The ADCP can be set to communicate at baud rates from 300 to 115200. The factory default baud rate is always 9600 baud. The baud rate is controlled via the CB-command. The following procedure explains how to set the baud rate and save it in the ADCP. This procedure assumes that you will be using the program *BBTalk* that is supplied by Teledyne RD Instruments.

```
[BREAK Wakeup A]
WorkHorse Broadband ADCP Version 16.28
RD Instruments (c) 1996-2005
All Rights Reserved.
>
>cr1
[Parameters set to FACTORY defaults]
```

Connect the ADCP to the computer and apply power.

Start the *BBTalk* program and establish communications with the ADCP. Wakeup the ADCP by sending a break signal with the **End** key.

At the ">" prompt in the communication window, type **CR1** then press the Enter key. This will set the ADCP to the factory default settings.

BAUD RATE	CB-command
300	CB011
1200	CB111
2400	CB211
4800	CB311
9600	CB411 (Default)
19200	CB511
38400	CB611
57600	CB711
115200	CB811

Send the CB-command that selects the baud rate you wish. The table on the left shows the CB-command settings for different baud rates with no parity and 1 stop bit.

For example, to change the baud rate to 115200, at the ">" prompt in the communication window, type **cb811** then press the Enter key.

The CB? command will identify the communication setting.

```
>cb?
CB = 411 ----------------- Serial Port Control (Baud
[4=9600]; Par; Stop)
>cb811
>CK
[Parameters saved as USER defaults]
>cb?
CB = 811 ----------------- Serial Port Control (Baud
[8=115200]; Par; Stop)
>
```

BBTalk will send the command **CK** to save the new baud rate setting.

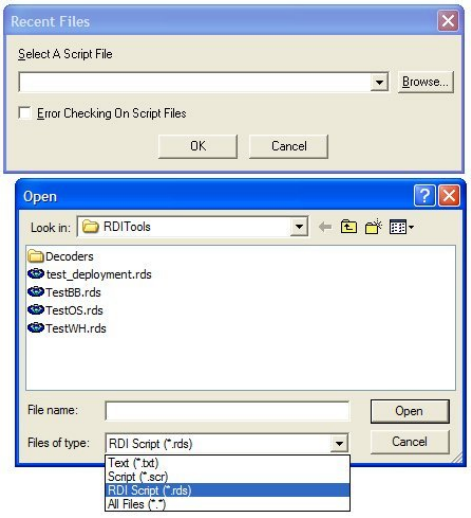
Exit *BBTalk*.

The ADCP is now set for the new baud rate. The baud rate will stay at this setting until you change it back with the CB-command.

Exit *BBTalk* so the communication port is available for use with other programs.

Testing the WorkHorse

Before deploying the WorkHorse ADCP, it is a good idea to make sure that it is working properly. This simple test checks that the WorkHorse ADCP is able to communicate with the computer and runs the diagnostic tests.



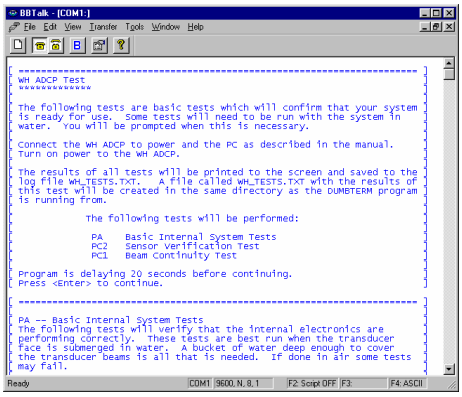
Testing the WorkHorse

Using *BBTalk*, click **File**, **Send a Break** to send the wakeup command (BREAK) to the WorkHorse ADCP.

On the **File** menu, click **Send Script File**. Click the **Browse** button "...".

On the **Files of Type** box select **RDI Script (*.rds)**.

Select the *TestWH.rds* script file and click **Open**.



Follow the prompts on the screen.

To review the test results, open the *WH_Test.txt* results log file (*.txt) with any text editor (i.e. NotePad).

Compass Alignment

The main reason for compass calibration is battery replacement. Each new battery carries a different magnetic signature. The compass calibration algorithm corrects for the distortions caused by the battery to give you an accurate measurement. You should be aware of the following items:

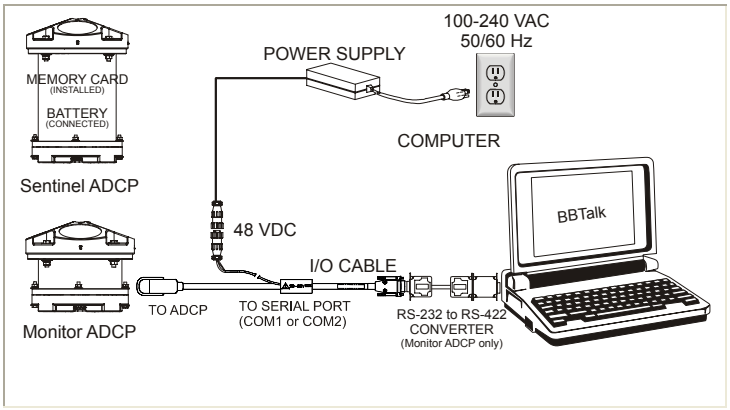
- We recommend against calibrating the WorkHorse ADCP while on a ship. The ship's motion and magnetic fields from the hull and engine will likely prevent successful calibration.
- If you think your mounting fixture or frame has some magnetic field or magnetic permeability, calibrate the WorkHorse ADCP inside the fixture. Depending on the strength and complexity of the fixture's field, the calibration procedure may be able to correct it.

NOTE. If the WorkHorse Sentinel battery module was removed and replaced back in the same orientation, the compass does not require calibration. If the battery core is replaced, you **must** verify the compass.

Battery replacement induces both single and double cycle compass errors. The compass accuracy should be **verified** after replacing the battery pack. The compass does not have to be recalibrated if the compass verification passes specification.

These compass effects can be avoided by using an optional external battery pack. The external battery housing holds two batteries, and can easily be replaced on-site. If the external battery is placed a minimum of 30 cm away from the WorkHorse ADCP, no compass calibration will be required.

Preparing for Calibration



Connect the WorkHorse ADCP as shown.

Place the WorkHorse ADCP on a piece of strong cardboard on top of a smooth wooden (non-magnetic) table. If a wooden table is not available, place the ADCP on the floor as far away from metal objects as possible. Use the cardboard to rotate the ADCP during calibration—this way you will not scratch the ADCP. Place the ADCP in the same orientation as it will be deployed.

NOTE. If you will deploy your WorkHorse ADCP looking up, calibrate it looking up. If you will deploy it looking down, calibrate it looking down.

CAUTION. If you calibrate the compass in one direction (up or down) and deploy the WorkHorse ADCP in the opposite direction (i.e. calibrate it in a downward position and deploy it in an upward position) the compass calibration will be invalid. Compass errors in excess of 5 degrees may occur.

Compass Calibration Verification

Compass calibration verification is an automated built-in test that measures how well the compass is calibrated. The procedure measures compass parameters at every 5º of rotation for a full 360º rotation. When it has collected data for all required directions, the ADCP computes and displays the results.

```
[BREAK Wakeup A]
WorkHorse ADCP Edition 43.xx
Teledyne RD Instruments (c) 1996-2006
All Rights Reserved.
                          >
```

Using *BBTalk,* send a Break to wake up the WorkHorse ADCP (press the **END** key).

```
>AX
------------------------------------------------------------------------
                    RDI Compass Error Estimating Algorithm

   Press any key to start taking data after the instrument is setup.
   Rotate the unit in a plane until all data samples are acquired...
   rotate less than 5º/sec.  Press Q to quit.
N       NE       E        SE       S        SW       W        NW       N
^                ^                 ^                 ^                 ^
```

At the > prompt, type **AX** and press the **Return** key.

```
HEADING ERROR ESTIMATE FOR THE CURRENT COMPASS CALIBRATION:
   OVERALL ERROR:
      Peak Double + Single Cycle Error (should be < 5():   ( 1.55(
   DETAILED ERROR SUMMARY:
      Single Cycle Error:                                  ( 1.54(
      Double Cycle Error:                                  ( 0.07(
      Largest Double plus Single Cycle Error:              ( 1.61(
      RMS of 3rd Order and Higher + Random Error:          ( 0.31(
```

Rotate the WorkHorse ADCP slowly 360 degrees (approximately 5 degrees per second). Pay particular attention to the Overall Error.

If the overall error is less than 2°, the compass does not require alignment. You can align the compass to reduce the overall error even more (if desired).

Compass Calibration Procedure

The built-in automated compass calibration procedure is similar to the alignment verification, but requires three rotations instead of one. The WorkHorse ADCP uses the first two rotations to compute a new calibration matrix and the third to verify the calibration. It will not accept the new matrix unless the calibration was carried out properly, and it asks you to verify that you want to use the new calibration if it is not as good as the previous calibration. While you are turning the WorkHorse for the two calibration rotations, the WorkHorse ADCP checks the quality of the previous calibration and displays the results. It compares these results with the results of the third calibration rotation.

There are two compass calibrations to choose from; one only corrects for hard iron while the other corrects for both hard and soft iron characteristics for materials rotating with the WorkHorse ADCP. Hard iron effects are related to residual magnetic fields and cause single cycle

errors while soft iron effects are related to magnetic permeability that distorts the earth's magnetic field and causes double cycle errors. In general, the hard iron calibration is recommended because the effect of hard iron dominates soft iron. If a large double cycle error exists, then use the combined hard and soft iron calibration.

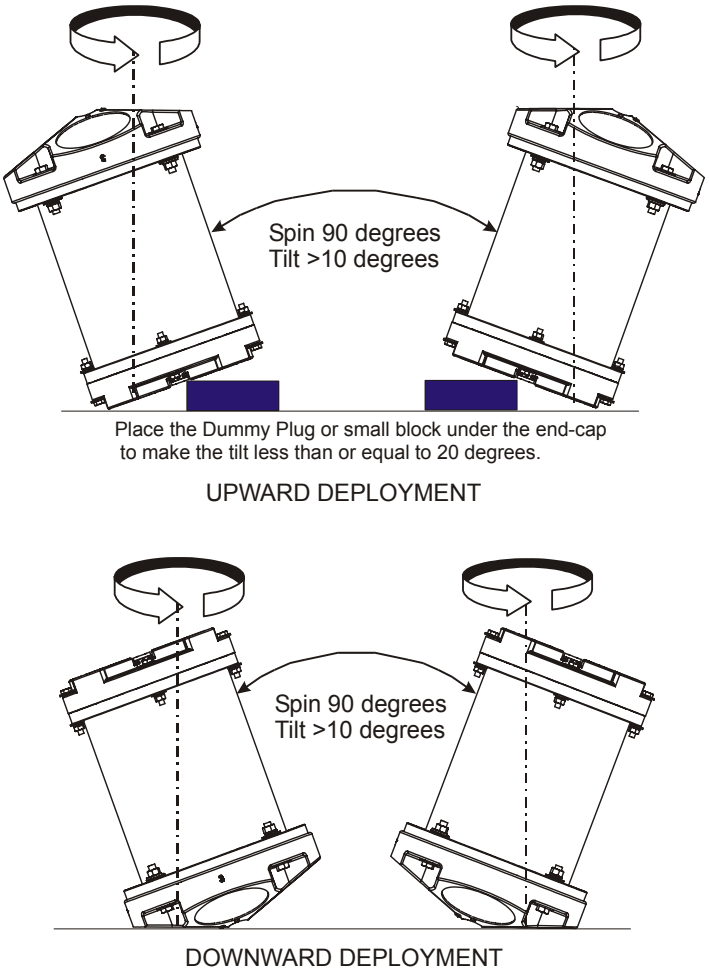


Figure 8. Compass Calibration

```
[BREAK Wakeup A]
WorkHorse ADCP Edition 43.xx
Teledyne RD Instruments (c) 1996-2006
All Rights Reserved.
>
```

Using *BBTalk,* send a Break to wake up the WorkHorse ADCP (press the **END** key).

```
>AR
Do you really want to write over the active fluxgate calibration
   data [y or n]?Y

Fluxgate Calibration Matrices Updated with Factory Original Values.

>
```

At the > prompt, type **AR** and press the **Return** key. Type **Y** to return the Fluxgate Calibration Matrices with the factory original values.

```
>AF
------------------------------------------------------------------------
                          Field Calibration Procedure
Choose calibration method:
     a.  Remove hard iron error (single cycle) only.
     b.  Remove hard and soft iron error (single + double cycle).
     c.  Help.
     d.  Quit.
```

At the > prompt, type **AF** and press the **Return** key. Choose option "b" to start the calibration procedure.

```
Tilt the unit any direction so that the combined tilt magnitude is
within the 10°-20° range indicated below.

0°                  10°                 20°                 30°
^                    ^***** ok tilt *****^                   ^
                                         ♦
  0.4° Pitch and 19.1° Roll are acceptable.  Ok to continue [y, n]?
```

Tilt the WorkHorse ADCP. Tilt an upward-looking WorkHorse with a block under one side of the end-cap. A 35-mm block will give you an 11-degree tilt. Tilt a downward looking WorkHorse by placing it on one of the beams.

Check the on-screen instructions to see if the orientation is OK. Adjust as necessary.

When prompted, press "**y"** to continue and rotate the WorkHorse ADCP slowly 360 degrees (approximately 5 degrees per second).

```
Now tilt the unit at least 10° in a different direction.

SUGGESTIONS:
  Facing up: place the block under the end cap to either side of where
  the block was for the first rotation - not on the opposite side
  of the end cap!.

  Facing down: place the ADCP facing down on either of the two beams
  that are closest to the one you just used.  Do not place the ADCP
  on the opposite beam.

-19.3° Pitch and -0.5° Roll. Tilt is OK. Press any key to continue...
```

The second rotation requires the WorkHorse ADCP to be tilted 15 degrees in another direction than from the first rotation. Follow the on-screen instructions to orient the WorkHorse ADCP correctly.

When prompted, press any key to continue and rotate the WorkHorse slowly 360 degrees (approximately 5 degrees per second).

```
Successfully evaluated compass performance after the field calibration
update.
Press any key to continue...
Making new calibration parameters permanent.
Calibration parameters have been updated in RAM and Flash.

------------------------------------------------------------------------
                          Field Calibration Procedure
                        Hard and Soft Iron Calibration

Compass field calibration procedure is complete.

>>> Total error before calibration:   2.3° <<<
>>> Total error after calibration:    0.2° <<<
```

The third rotation requires the WorkHorse ADCP to be tilted 15 degrees in another direction than from the first and second rotations. Follow the on-screen instructions to orient the WorkHorse correctly.

If the calibration procedure is successful, it records the new calibration matrix to nonvolatile memory. The WorkHorse will not change its matrix unless the calibration is properly carried out.

Optional Pressure Sensor Preparation

In order to read the water pressure (depth), water must be able to flow through the copper screw on the pressure sensor. Antifoulant paint will block the sensor's port (a small hole that is drilled through the copper screw). You should tape off the screw during anti-fouling paint application.

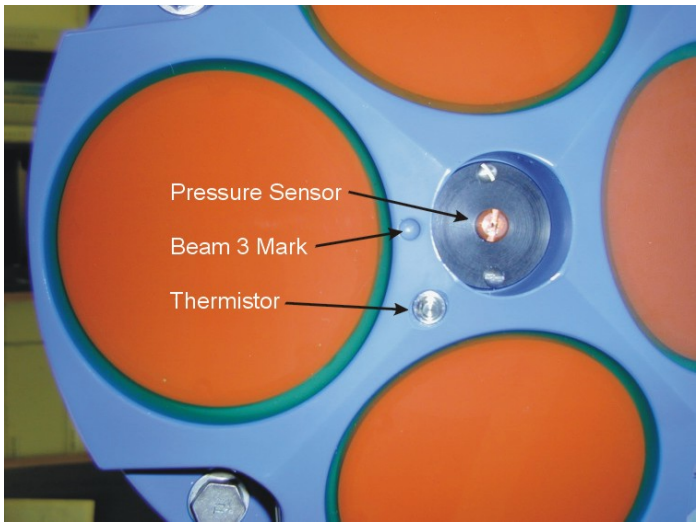
This means that the sensor port is not fully protected from bio fouling. The sensor port is surrounded by the antifouling paint, but bio fouling may build up on the screw, and eventually clog the sensor port. However, most organisms do not seem to find the small amount of unpainted surface attractive. If it is logistically possible to periodically inspect/clean the pressure sensor screw, it is highly recommended. This tradeoff situation must be analyzed for individual deployments. Unfortunately, the location of the deployment site usually dictates action in this regard.

NOTE. The pressure sensor is optional. It may not be included on your system.

CAUTION. The pressure sensor is filled with silicone oil. Never poke a needle or other object through the copper screw while the screw is installed over the pressure sensor. You will perforate the sensor, causing it to fail.

Do not remove the cover disc or attempt to clean the surface of the pressure sensor. The diaphragm is very thin and easy to damage.

Do not remove the pressure sensor. It is not field replaceable.



Use the following procedure to clean the screw.

Place the WorkHorse on its' end-cap. Use a soft pad to protect the WorkHorse.

Use a straight-slot screwdriver to remove the copper screw.

Gently clean out the hole in the copper screw with a needle.

Install the copper screw. Tighten the screw "finger tight" (0.226 N-m, 2 lbf-in).

CAUTION. Do not over tighten the screw or you may strip the threads on the plastic cover disc. If this happens, return the WorkHorse ADCP to TRDI for repair.

```
[BREAK Wakeup A]
WorkHorse ADCP Edition 43.xx
Teledyne RD Instruments (c) 1996-2006
All Rights Reserved.
>

>

>
>AZ
>
```

Zero the Pressure Sensor

Use the AZ-command to zero out the pressure sensor at the deployment site, before putting the WorkHorse into the water.

Connect and apply power to the system.

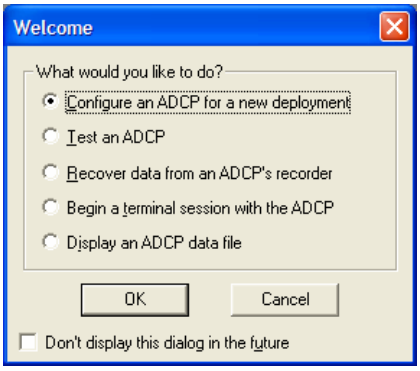
Start *BBTalk* and wakeup the WorkHorse ADCP (press the **END** key).

Type **AZ** and press the Return key.

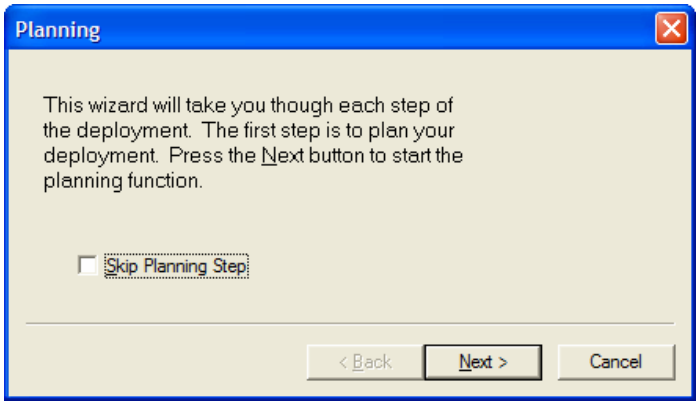
Exit *BBTalk*.

Collecting Self-Contained Data

WinSC works as a shell program to launch the *PlanADCP* program. *PlanADCP* is designed to create a command file that will be used to set up a WorkHorse ADCP for collecting data. In this example we will start *WinSC*, use *PlanADCP* to develop the command file, and then go back to the *WinSC* program to continue with the testing, deployment, and recovery of data.



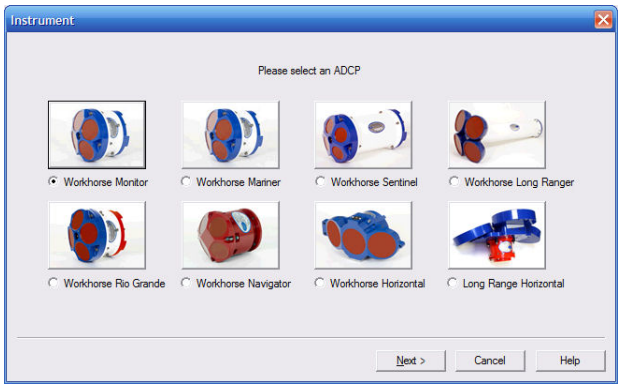
Start *WinSC*. Select **Configure an WorkHorse for a new deployment** and click **OK**.



Planning

The first step of the deployment wizard will start *PlanADCP*.

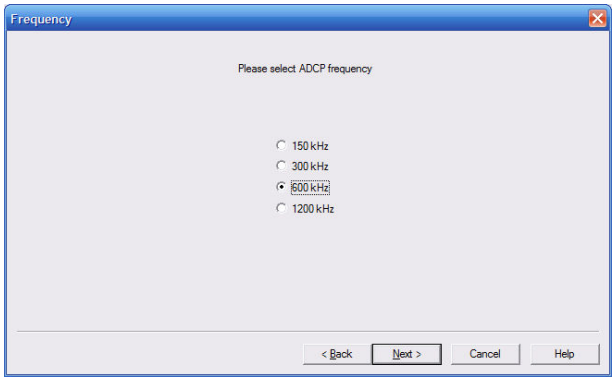
Click **Next** to continue.



Instrument

Select the type of WorkHorse ADCP you want to create a command file for.

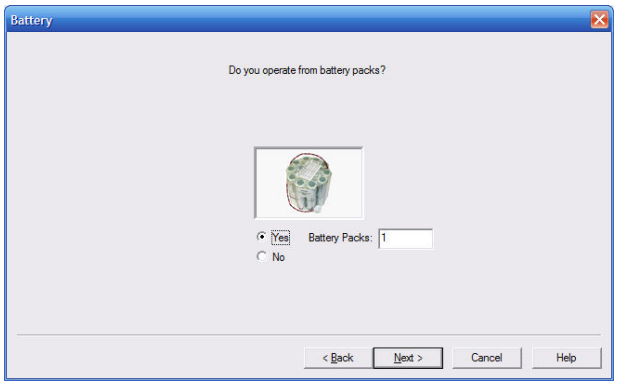
Click **Next** to continue.



Frequency

Select the frequency of your WorkHorse. The default settings and consequences are based upon the WorkHorse frequency.

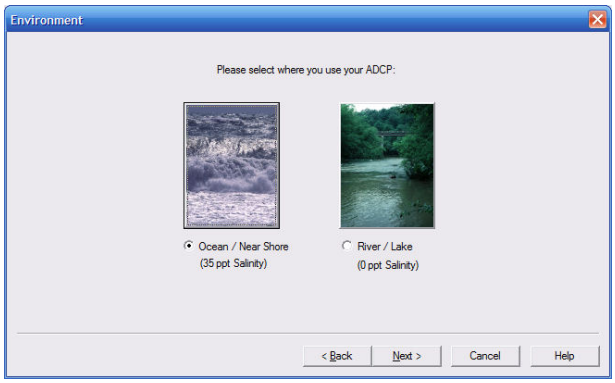
Click **Next** to continue.



Battery

Select if the WorkHorse has internal batteries. If you select **Yes**, then enter the number of battery packs you are going to use.

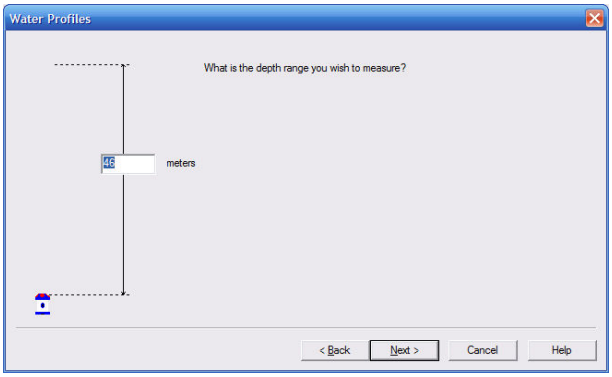
Click **Next** to continue.



Environment

Select **Ocean/Near Shore** or **River/Lake** to set the salinity. Water salinity affects the maximum range. Salt water is typically 35 ppt, fresh water is 0 ppt.

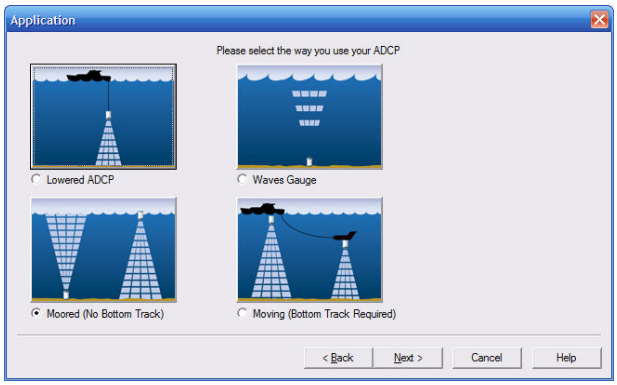
Click **Next** to continue.



Water Profiles

Select the depth range you wish to measure. The maximum depth range is dependent on the WorkHorse frequency, water salinity, water temperature, and the depth of the WorkHorse.

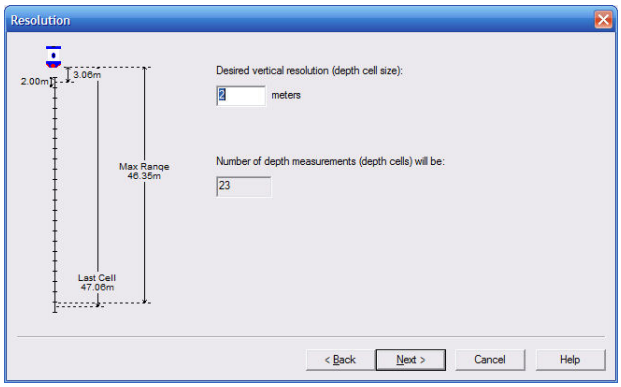
Click **Next** to continue.



Application

Select **Moored (No Bottom Track)** for a self-contained deployment.

Click **Next** to continue.

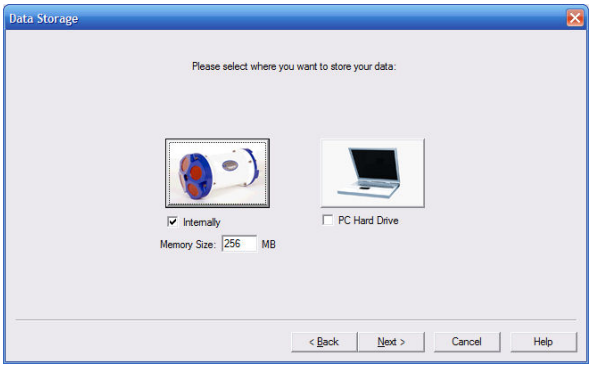


Resolution

Set the depth cell (bin) size. Adjust the depth cell (bin) size as necessary to get at least 10 depth cells (bins). A larger depth cell (bin) size decreases the standard deviation, but shallow water situations may need to use small depth cells (bins) to get more data points.

PlanADCP will set the number of depth cells (bins) so that the consequence *last depth cell (bin) range* is approximately 10% greater than the depth range set in the previous step.

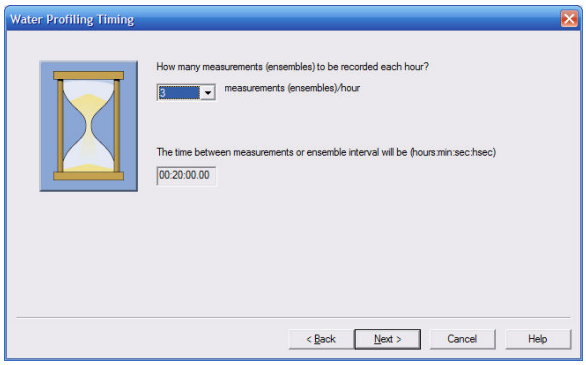
Click **Next** to continue.



Data Storage

Select where to store the data. Data can be stored internally, sent out the serial port, or both. If you selected **Internally**, enter the amount of memory installed.

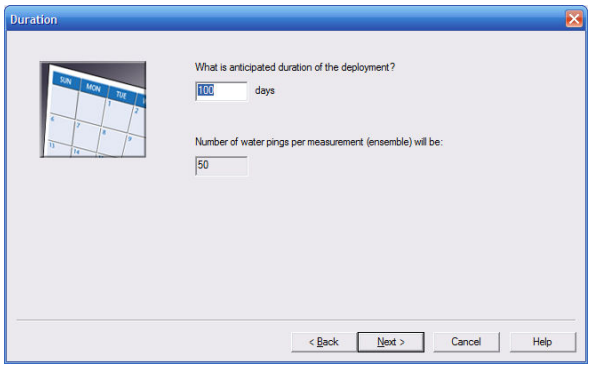
Click **Next** to continue.



Water Profiling Timing

Select how many ensembles per hour you want to record.

Click **Next** to continue.

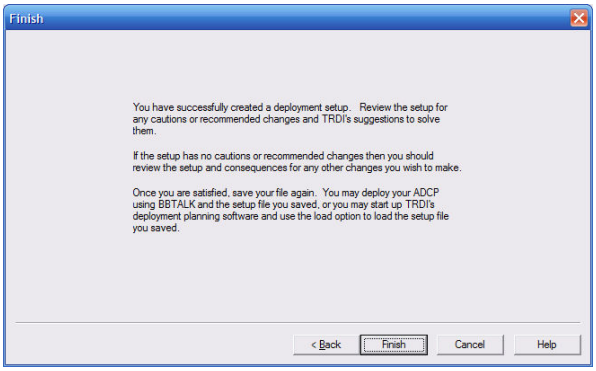


Duration

Enter the expected duration of the WorkHorse deployment from the time of the first water profiling ping (either immediately or first ping date/time). This duration *does not* produce a command to instruct the WorkHorse to stop data collection; it is for estimating consequences only. This duration is used to estimate the following *consequences*:

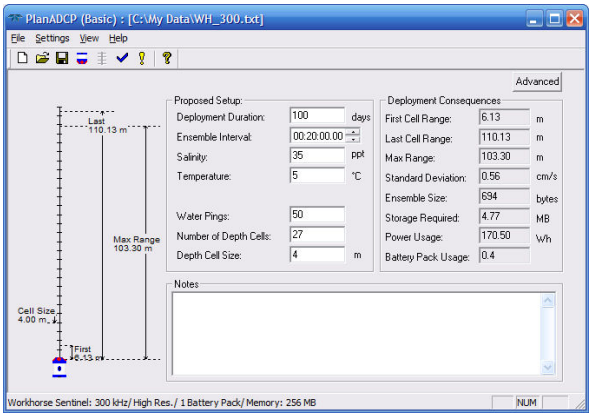
- Battery usage
- Ensembles
- Storage required

Click **Next** to continue.



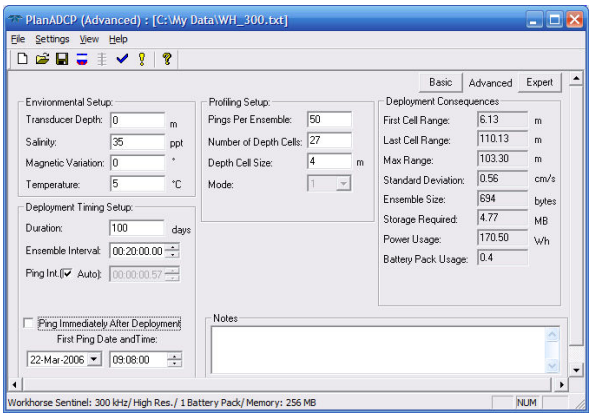
The wizard is now finished.

Click **Finish**.



The *PlanADCP* (Basic) Screen opens using the settings you selected with the wizard. Review the consequences (see the WinSC and PlanADCP User's Guide for details).

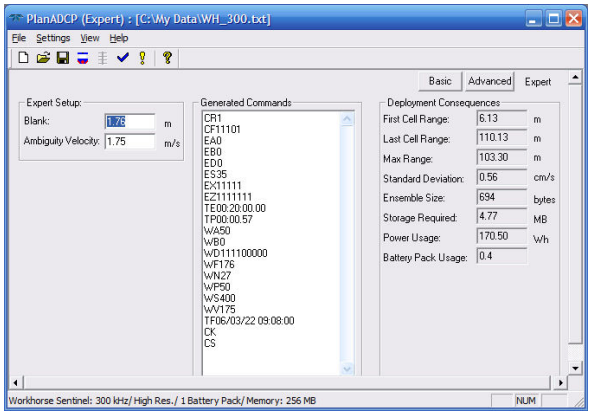
On the *PlanADCP* (Basic) Screen click the **Advanced** button to bring up the **Advanced** setting screen.



Advanced Screen

Uncheck the **Ping Immediately After Deployment** box and enter a date and time you want the WorkHorse to begin pinging.

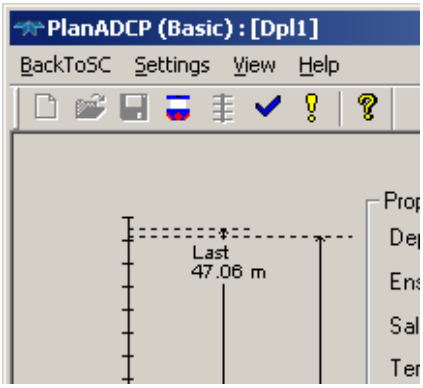
Start sample intervals on the minute by using a delayed start up. Instead of having your 10-minute sample intervals start at 12:36:47, delay startup a few minutes to have samples start at 13:00:00.



Expert Screen

On the *PlanADCP* (Advanced) Screen click the **Expert** button to bring up the **Expert** setting screen.

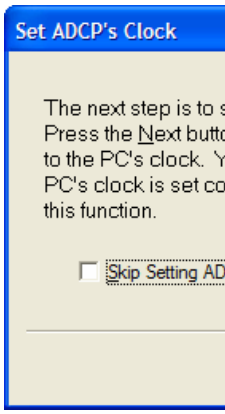
You can view the commands that will be sent to the WorkHorse.



Back to WinSC

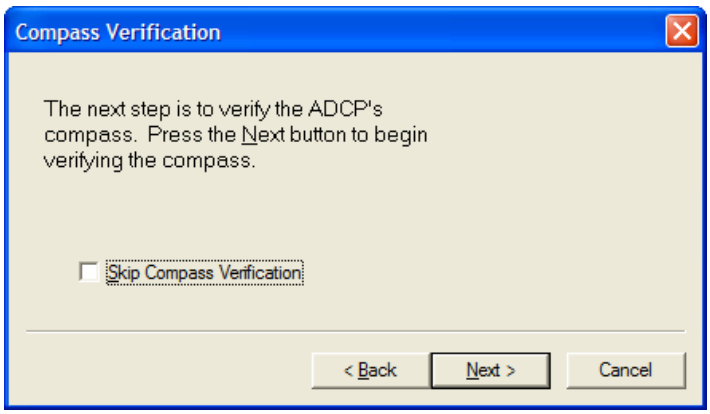
Click the **BackToSC** menu to return to *WinSC*.

NOTE. At this point, the WorkHorse ADCP should be prepared for deployment, using battery power, and sealed.



The second step will set the WorkHorse ADCP's clock to the computer's time and date using the TS-command.

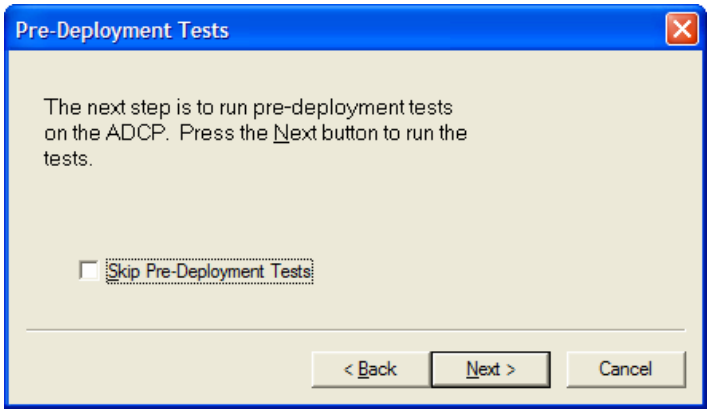
Click **Next** to continue.



The third step will verify the compass using the AX-command.

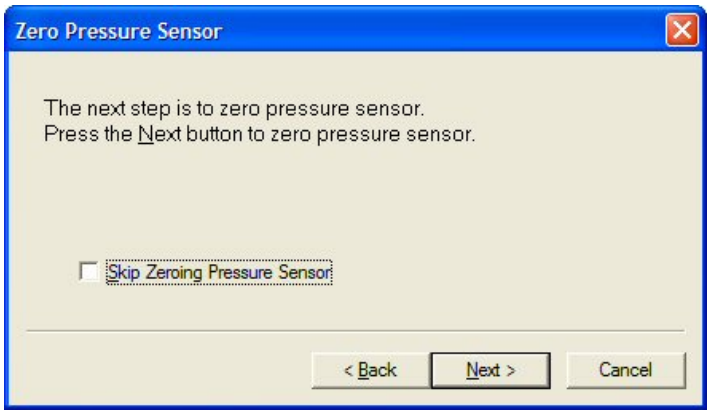
Note: If the internal batteries were replaced, this step will only *verify* the compass; you must *align* the compass prior to using the *WinSC* wizard.

Click **Next** to continue.



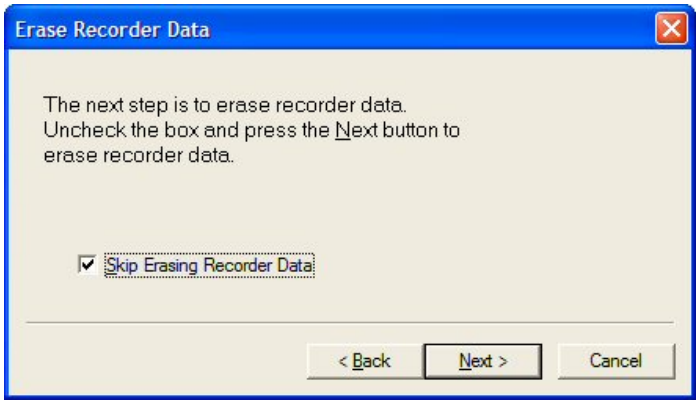
The fourth step will run the pre-deployment tests Deploy?, System?, TS?, PS0, PA, PC2, RS, and PC1-commands.

Click **Next** to continue.



The fifth step will zero the pressure sensor using the AZ-command.

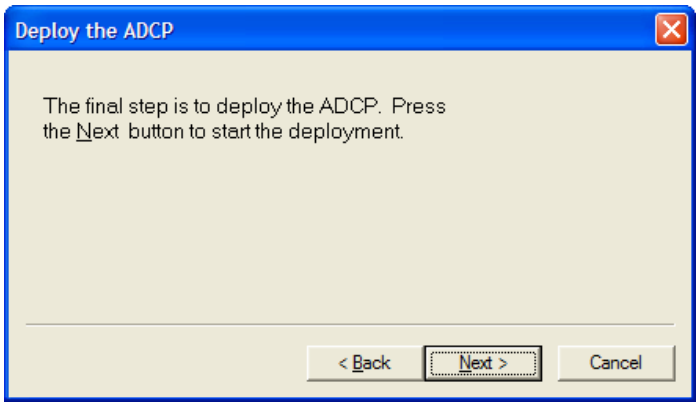
Click **Next** to continue.



The sixth step will erase the recorder using the RE-command. Uncheck the **Skip Erasing Recorder Data** box if you want to erase the data.

CAUTION: Once erased, the data is not recoverable.

Click **Next** to continue.



The seventh and final step in the Deployment Wizard will send the commands from the command file to the WorkHorse.

Click **Next** to send the commands. When the commands have been sent to the WorkHorse, you should see a message "*You have successfully deployed the ADCP*."

Click **OK**.

NOTE. The WorkHorse must be powered with the batteries, sealed, and ready to deploy before you click **Next**.

Save Deployment File

If you have not already saved the deployment file, you will be prompted to name the deployment. Choose and use Deployment Names carefully: they help you identify and organize all the data and log files associated with each deployment.

The command file and deployment log file will be saved when the deployment file is saved. For example, if you save the deployment file as *Dpl1_.dpl*, then the command file will be saved as *Dpl1_.whp* and the log file will be saved as *Dpl1_.scl.*

Before deploying the WorkHorse ADCP, scroll through the deployment log file and look for error messages. Correct as needed and re-send the commands.

Photo courtesy of J. Bornhoeft.

Deploy and Recover the WorkHorse

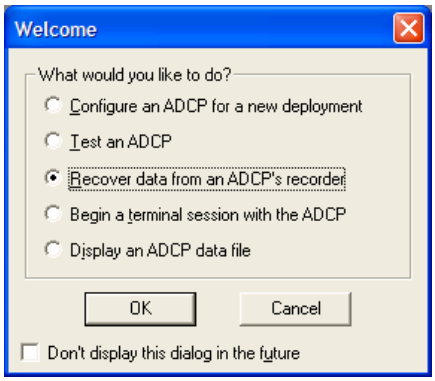
Once the commands have been sent to the WorkHorse, proceed as follows.

- Disconnect the I/O cable and install the dummy plug on the WorkHorse ADCP's end-cap.
- Deploy the WorkHorse ADCP.

CAUTION. Do not send a break, any other command, or run any other programs once the commands have been sent to the WorkHorse ADCP or your commands will be over-written.

Disconnect the I/O cable before turning off power to the computer. Some computers may send a break signal out the serial ports when shutting down.

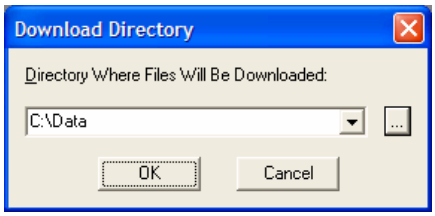
Recover Data with WinSC



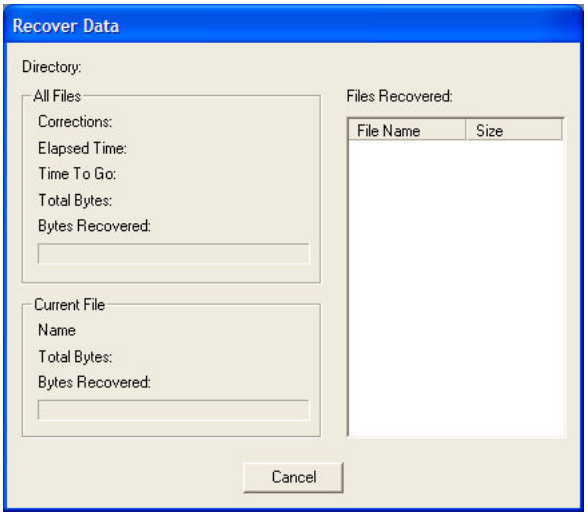
Connect and power up the WorkHorse ADCP.

Start *WinSC*.

At the **Welcome Screen** select **Recover Data from an ADCP's Recorder** or from the **File** menu, select **Recover Recorder Data**.

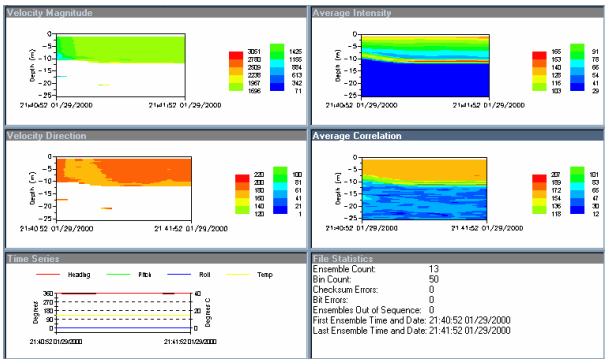


Select the directory where the data will be written.



WinSC will increase the baud rate set in the **Com Settings** window to 115200 BAUD to reduce the download time.

Viewing Data with *WinSC*

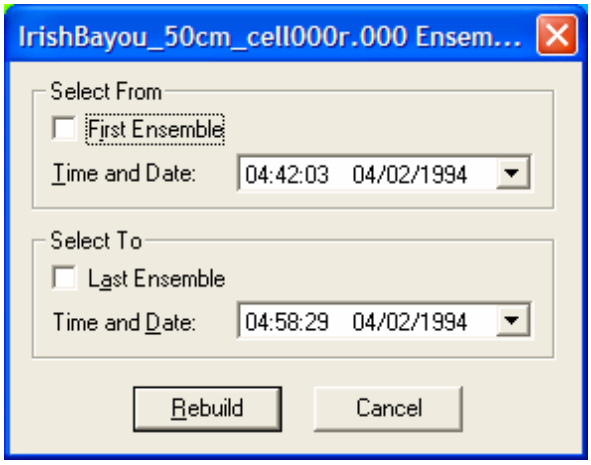


On the **File** menu, click **Open**.

On the **Files of Type** box, select **ADCP Data** (*.0*).

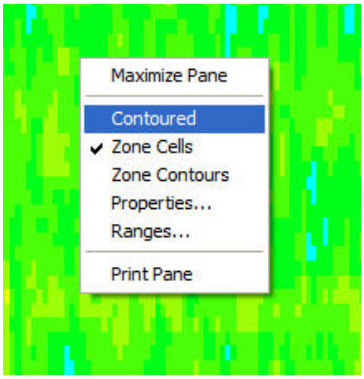
Select the file and click **Open**.

The data file will display all of the ensembles.



To select a subsection of the data file, use the **View** menu, **Ensemble Selection**.

To quickly select a section, hold the **Control** key while dragging the mouse over the area to be selected.



Display Controls.

Right-click inside any window to bring up the display menu.

To increase the size of a window, click **Maximize Pane** button.

To increase the contrast of the contoured plot, select **Contoured**.

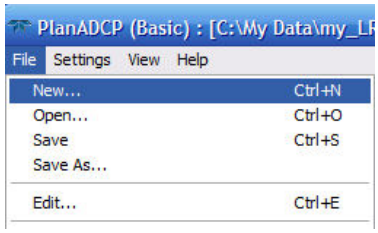
You can increase the contrast between cells and contours by using the **Zone Cells** or **Zone Contours**.

To change the colors of the plot or other plot controls, click **Properties**.

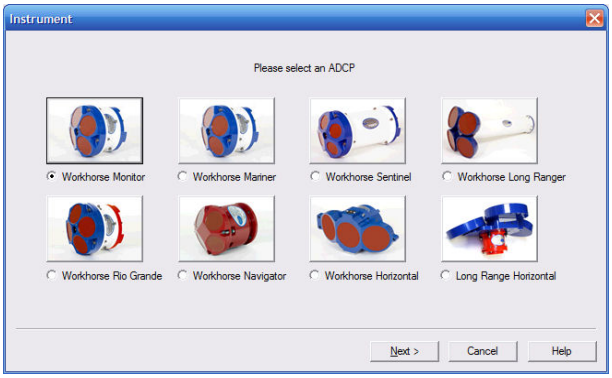
To select the range of a contoured plot, click **Ranges**.

Collecting Real-Time Data

PlanADCP is designed to create a command file that will be used to set up a WorkHorse ADCP for collecting data. In this example we will use *PlanADCP* to develop the command file, and *BBTalk* to send the commands to the WorkHorse. Then we will use the *WinADCP* program to view the data in real-time.



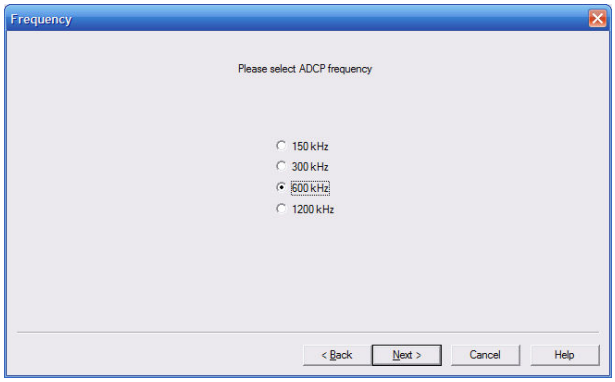
Start *PlanADCP*. On the **File** menu, click **New**.



Instrument

Select the type of WorkHorse ADCP you want to create a command file for.

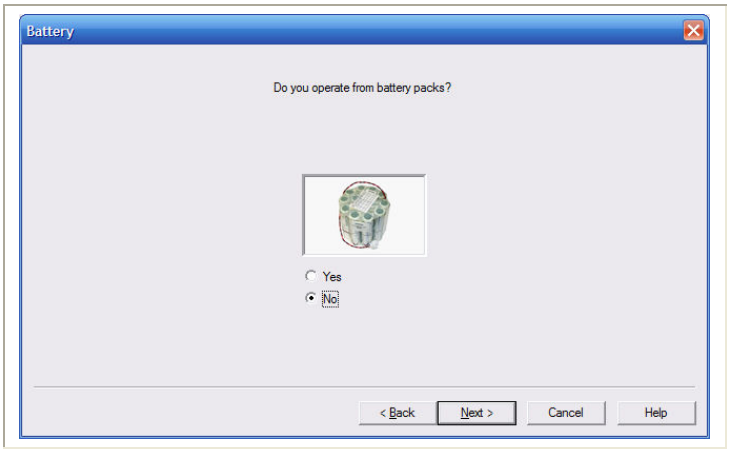
Click **Next** to continue.



Frequency

Select the frequency of your WorkHorse ADCP. The default settings and consequences are based upon the WorkHorse frequency.

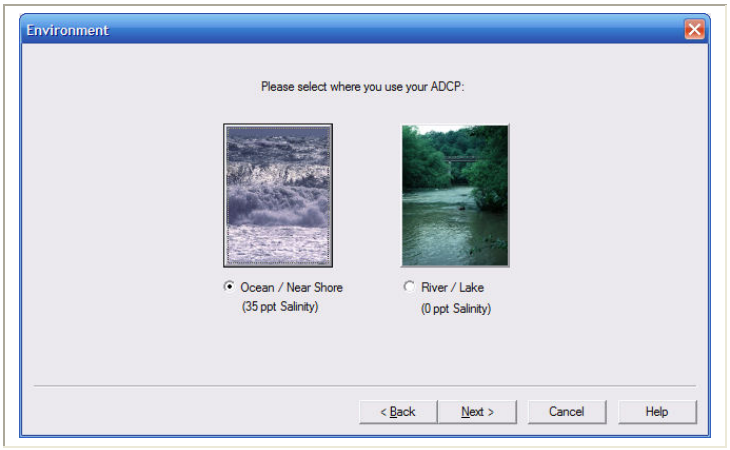
Click **Next** to continue.



Battery

Select if the WorkHorse has internal batteries. If you select **Yes**, then enter the number of battery packs you are going to use.

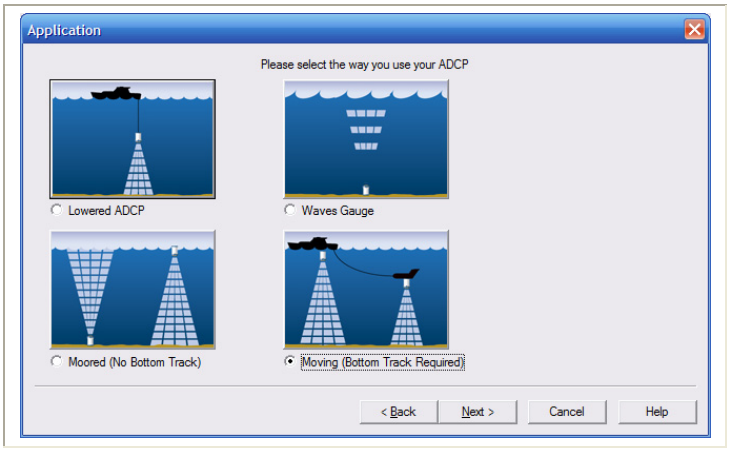
Click **Next** to continue.



Environment

Select **Ocean/Near Shore** or **River/Lake** to set the salinity. Water salinity affects the maximum range. Salt water is typically 35 ppt, fresh water is 0 ppt.

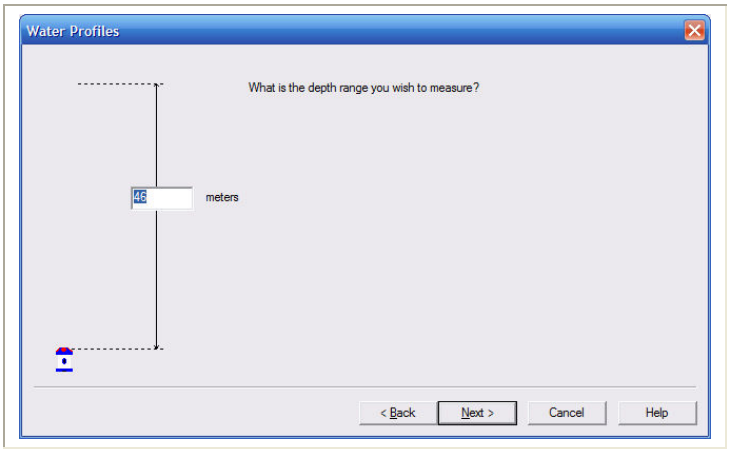
Click **Next** to continue.



Application

Select **Moored (No Bottom Track)** for a self-contained deployment.

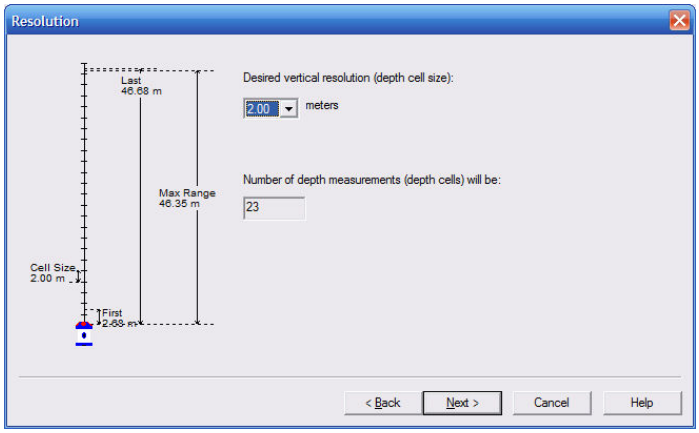
Click **Next** to continue.



Water Profiles

Select the depth range you wish to measure. The maximum depth range is dependent on the WorkHorse frequency, water salinity, water temperature, and the depth of the WorkHorse.

Click **Next** to continue.

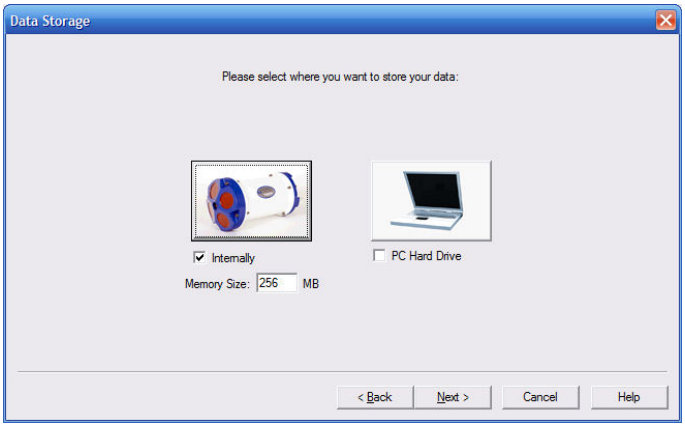


Resolution

Set the depth cell (bin) size. Adjust the depth cell (bin) size as necessary to get at least 10 depth cells (bins). A larger depth cell (bin) size decreases the standard deviation, but shallow water situations may need to use small depth cells (bins) to get more data points.

PlanADCP will set the number of depth cells (bins) so that the consequence *last depth cell (bin) range* is approximately 10% greater than the depth range set in the previous step.

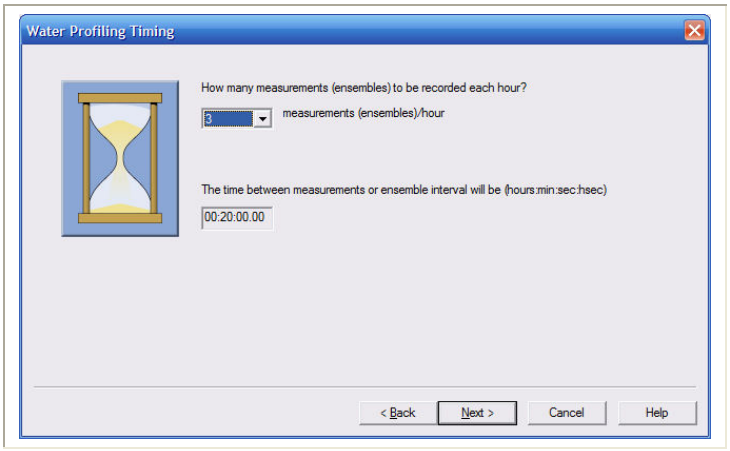
Click **Next** to continue.



Data Storage

Select where to store the data. Data can be stored internally, sent out the serial port, or both. If you selected **Internally**, enter the amount of memory installed.

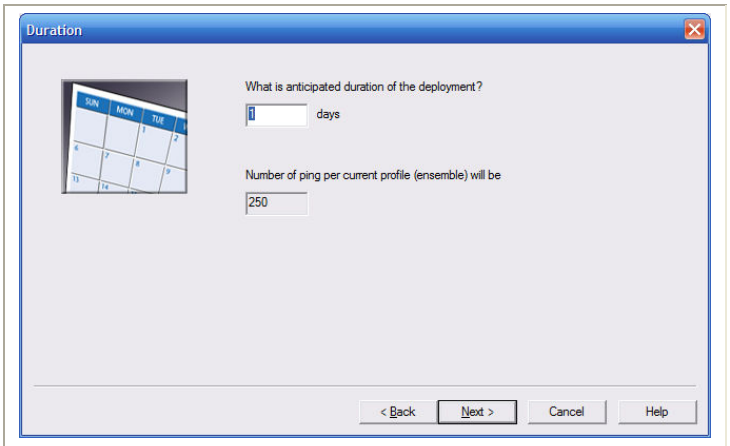
Click **Next** to continue.



Water Profiling Timing

Select how many ensembles per hour you want to record.

Click **Next** to continue.

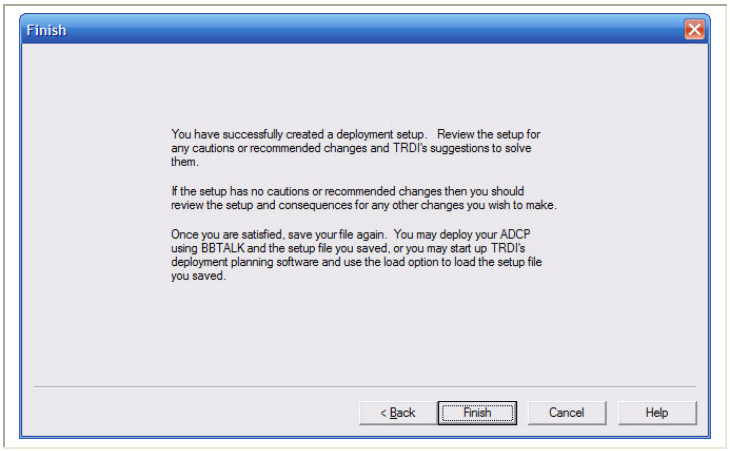


Duration

Enter the expected duration of the WorkHorse deployment from the time of the first water profiling ping (either immediately or first ping date/time). This duration *does not* produce a command to instruct the WorkHorse to stop data collection; it is for estimating consequences only. This duration is used to estimate the following *consequences*:

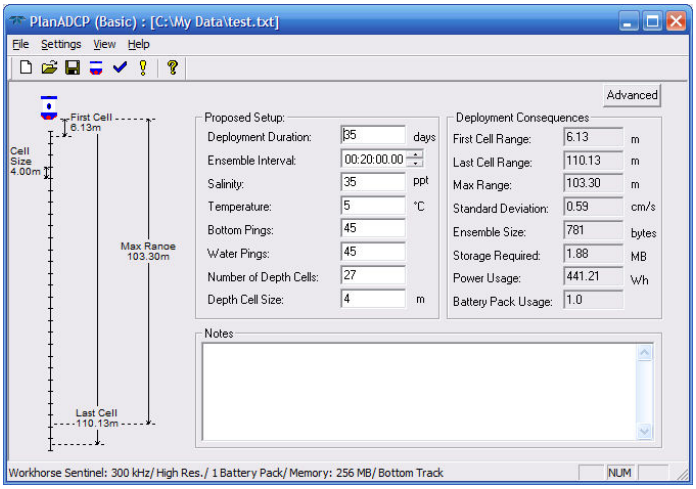
- Power requirements
- Ensembles
- Storage required

Click **Next** to continue.



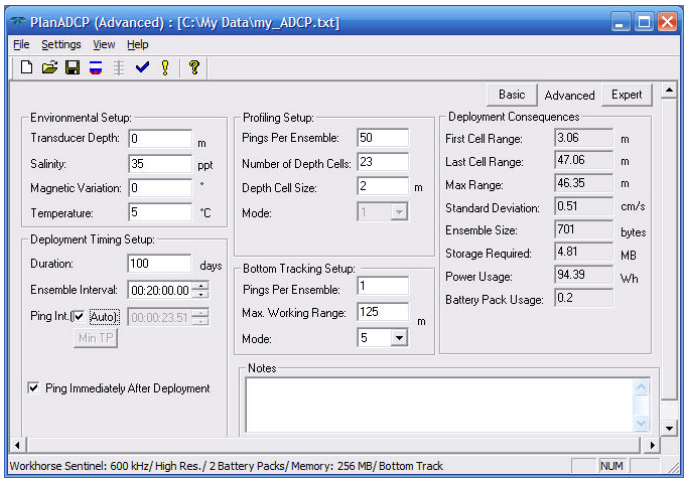
The wizard is now finished.

Click **Finish**.



The *PlanADCP* (Basic) Screen opens using the settings you selected with the wizard. Review the consequences (see the WinSC and PlanADCP User's Guide for details).

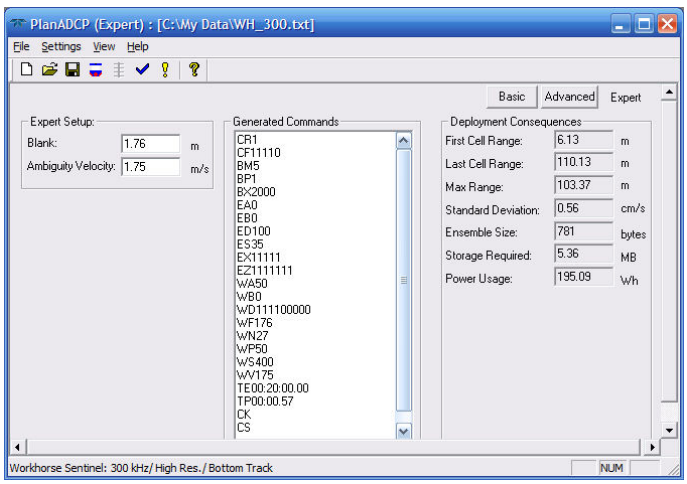
On the *PlanADCP* (Basic) Screen click the **Advanced** button to bring up the **Advanced** setting screen.



Advanced Screen

Uncheck the **Ping Immediately After Deployment** box and enter a date and time you want the WorkHorse ADCP to begin pinging.

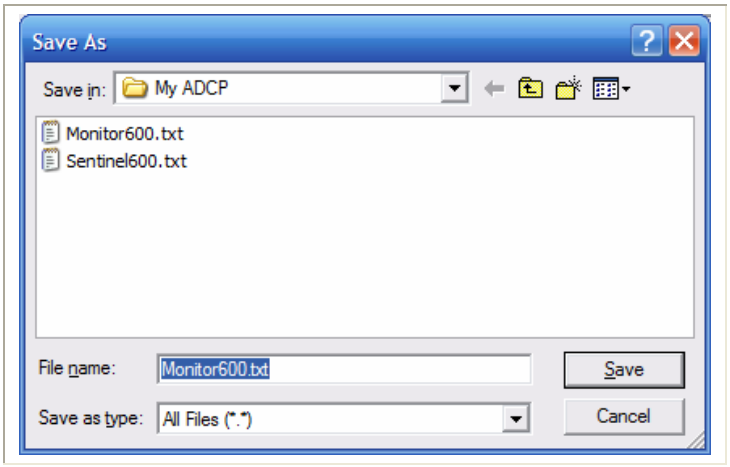
Start sample intervals on the minute by using a delayed start up. Instead of having your 10-minute sample intervals start at 12:36:47, delay startup a few minutes to have samples start at 13:00:00.



Setup Advanced Screen

On the *PlanADCP* (Advanced) Screen click the **Expert** button to bring up the **Expert** setting screen.

You can view the commands that will be sent to the WorkHorse.



Save the Command File

On the **File** menu, click **Save**. Name the command file and click **Save**.

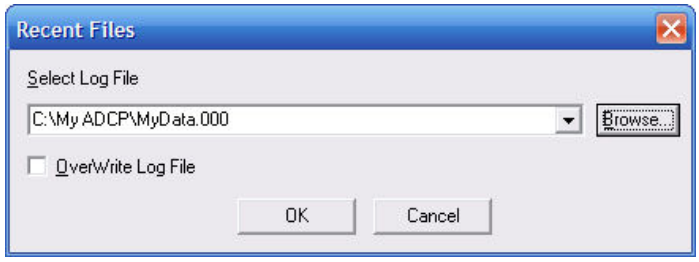
Sending the Commands to the WorkHorse ADCP

```
[BREAK Wakeup A]
WorkHorse ADCP 43.xx
Teledyne RD Instruments (c) 1996-2006
All Rights Reserved.
>
```

Wakeup the WorkHorse

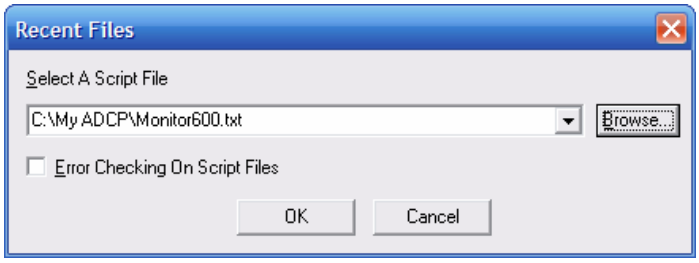
Start *BBTalk*. On the **File** menu, click **Break** (you can also press the **End** key to send a break or and press the **B** button on the Toolbar).

You should see the wakeup message appear on the log file window.



Create a Log File

Press **F3** and create a log file. Name the file and use **.000* for the file extension.



Send the Commands to the WorkHorse

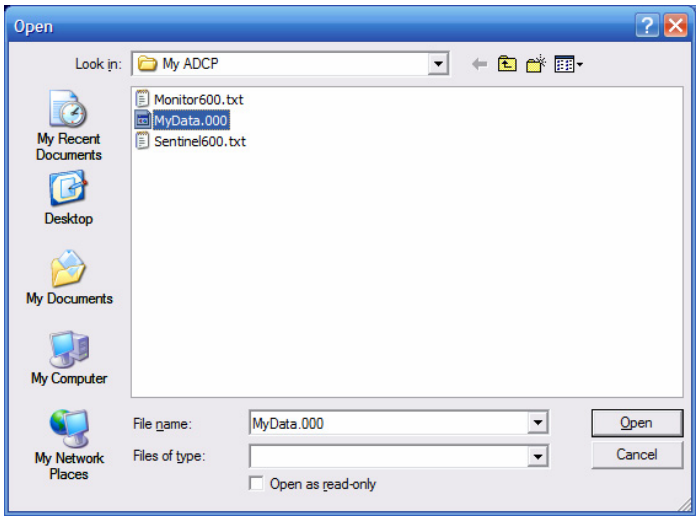
Press **F2** and use the **Browse** button to locate the command file.

You should see the commands appear on the log file window and the WorkHorse ADCP's response.

Carefully review the log file window and make sure that no command created an error message.

Viewing Data in Real-Time

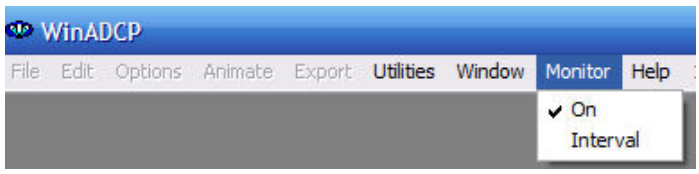
WinADCP has the ability to automatically update the reading of a file as real-time data collection is occurring. When the file size increases, (due to real-time data collection) **Monitor** will automatically reread the file at selected intervals and display the contents. When **Monitor** is enabled and the file size is changing, all menu items except **Monitor** will be unavailable.



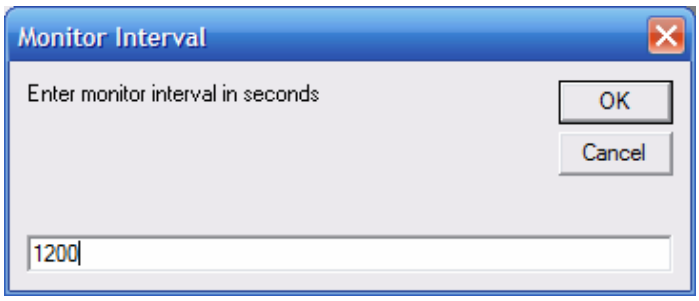
Start WinADCP

Start *WinADCP*. On the **File** menu, click **Open**.

Select the log file created with *BBTalk* (see "Sending the Commands to the WorkHorse ADCP," page 48).

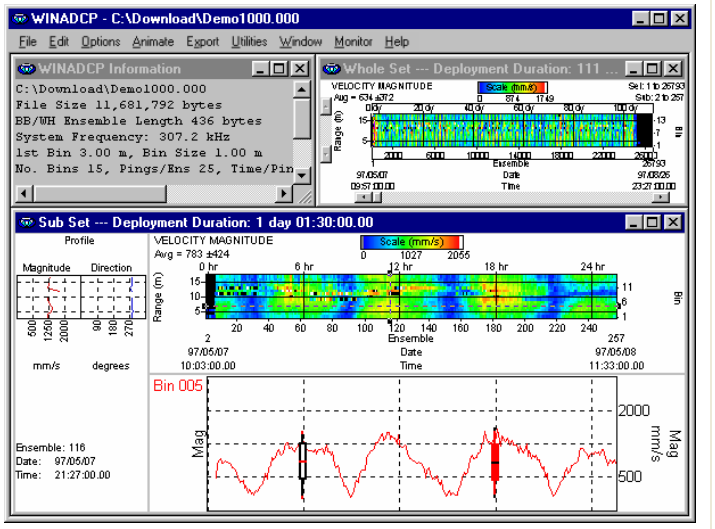


On the **Monitor** menu, select **ON**.

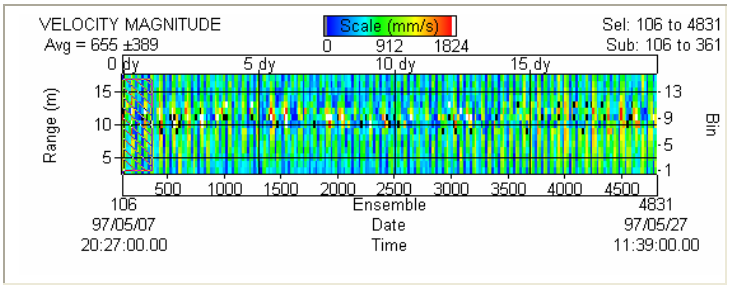


You can change the interval by clicking **Monitor**, **Interval**.

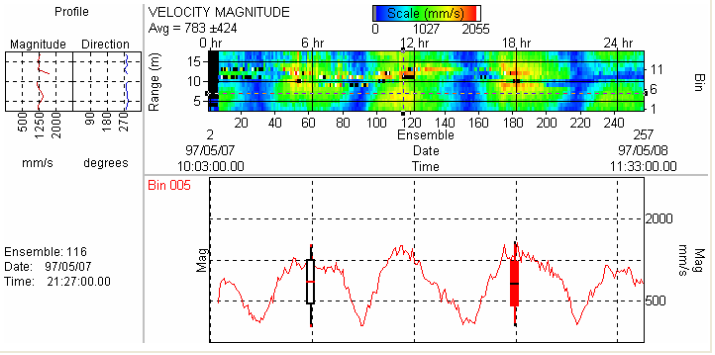
Enter the monitor interval in seconds. For example, a 20 minute ensemble would be 1200 seconds.



WinADCP has two main graphic display forms. The form located in the upper right portion of the screen is called the **Whole Set**. The form located across the bottom half of the display is called the **Sub Set**. Each of these forms displays a portion of the entire data set as a color contour. In addition to the color contour, **Sub Set** displays the user selected **Profile**, **Series**, and **Ancillary** data.



The **Whole Set** form is displayed in the upper right-hand portion of *WinADCP*. When a file containing a Binary Output Data Format is opened, the entire set of the selected data type is displayed as a color contour located within the **Whole Set** form.



By holding down the **Spacebar** and then pressing the **Left** mouse button, the user can drag the mouse to select a portion of the entire data set. When the mouse button is released, the selected portion of the **Whole Set** is marked by a blinking box outline. The blinking box outlines a set of data called the **Selected Set**.

Where to Find More Information

Congratulations! You have completed the WorkHorse Monitor/Sentinel User's Guide. For more detailed information, see the following sections in the WorkHorse Technical Manual.

Installation. Use this section to plan your installation requirements. This guide includes specifications and dimensions for the WorkHorse ADCP (including outline installation drawings).

Maintenance. This section covers WorkHorse ADCP maintenance. Use this section to make sure the WorkHorse is ready for a deployment.

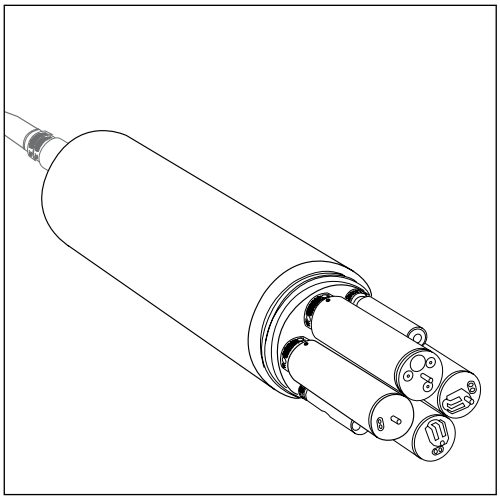
Test. Use this section to test the WorkHorse ADCP.

Troubleshooting. This section includes a system overview and how to troubleshoot the WorkHorse ADCP. If the WorkHorse fails a built-in test or you cannot communicate with the system, use this guide to help locate the problem.

Commands and Output Data Format. This section contains a reference for all commands and output data formats used by the WorkHorse ADCP.

NOTES

6-Series Sonde Quick Start Guide



This document will assist an experienced user with the steps required to make your YSI 6-Series product operational.

For full instructions, please refer to the 6-Series User Manual.

Unpacking and Inspection

Inspect the outside of the shipping container(s) for damage. If you see any damage, contact your shipping carrier immediately.

Remove the equipment from the shipping box. Some parts are loose in the box, so check the packing material carefully. Check off all items on the packing list and inspect them for damage.

Items Needed

- Sonde
- Probes
- Calibration cup
- Probe guard
- Batteries (if sonde has battery compartment)
- DI water
- Flathead screwdriver
- Calibration standards
- Communication or field cable

If using 6562 DO probe:

- 6570 maintenance kit
- 5775 membrane kit
- Razor blade

Preparing Sonde for Use

To prepare the sonde for operation, you will need to:

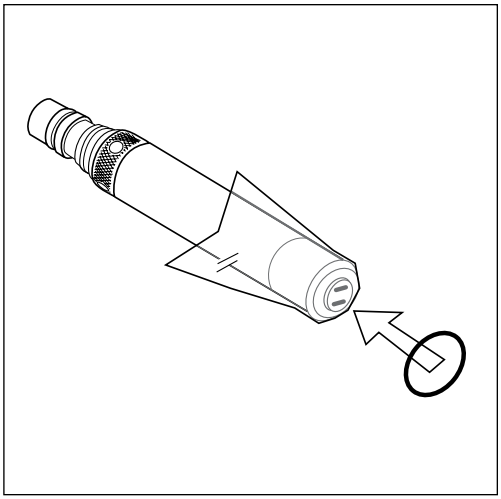
- Install a new membrane on the YSI 6562 DO Probe, if you are using this item.

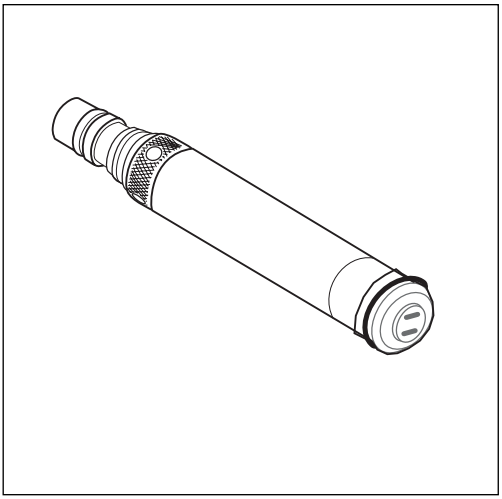
- Install probes (sensors) into the connectors on the sonde bulkhead.

- Provide power for the sonde through batteries or line power.

- Connect a field cable or PC communication cable.

⚠ It is important to calibrate all sensors prior to using the sonde for field measurements. Refer to Section 2.6.2 of the 6-Series User Manual.





Installing Membrane on 6562 DO Probe

(Skip to next section if you are not using this probe)

The 6562 Rapid Pulse™ Dissolved Oxygen probe is shipped with a protective dry membrane on the sensor tip. Remove the O-ring and membrane. Handle the probe with care. It is important not to scratch or contaminate the sensor tip.

⚠ The DO sensor on the 600R/QS cannot be removed.

Open the 6562 DO Probe Kit and follow these steps:

1. Prepare the electrolyte solution as specified on the bottle.

2. Put/keep the protective cap on the connector end of the probe to protect it from contamination.

3. Hold the probe in a vertical position and apply a few drops of KCl solution to tip. The fluid should completely fill the small moat around the electrodes—and create a large meniscus on the probe face. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off electrolyte and start over.

4. Secure a membrane between your left thumb and the probe body. Touch membrane only at the ends.

5. With the thumb and forefinger of your right hand, grasp the free end of the membrane and gently stretch it up, over, and down the other side of the sensor. The membrane should be stretched below the ridge where the O-ring seats so a good seal is achieved.

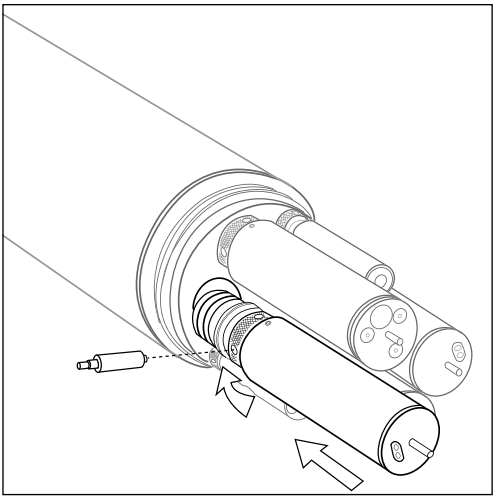
6. Secure the end of the membrane under the forefinger of your left hand.

7. Roll the O-ring over the end of the probe, being careful not to touch the membrane surface with your fingers.

8. If bubbles or wrinkles are present, remove the membrane and repeat steps 3-7.

9. Trim excess membrane with a razor blade. Rinse off any excess KCl solution, but be careful not to get any water in the connector.

Refer to Section 2.3 of the 6-Series User Manual for complete instructions and photos.



⚠ *When installing probes, be careful not to cross-thread the probe nuts. If you meet resistance while finger-tightening, STOP, back out, and begin again.*

Installing Probes

⚠ Before installing any probe into the sonde bulkhead, be sure that the probe port is free of moisture. Use a Kimwipe™ or lint-free cloth to dry.

1. Remove the calibration cup from your sonde, if necessary.

2. Using the long end of the probe installation tool supplied in the 6570 Maintenance Kit, remove the port plug from the port.

3. Some probes can only be installed into specific ports. Refer to Section 2.3 of the 6-Series User Manual for port designations.

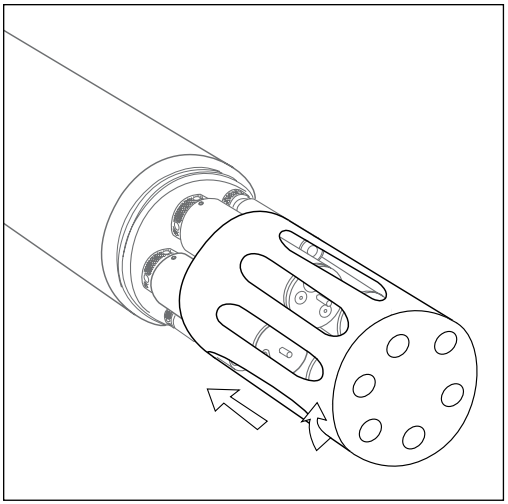
4. Apply a thin coat of lubricant (Krytox™) to the O-rings on the connector side of the probe.

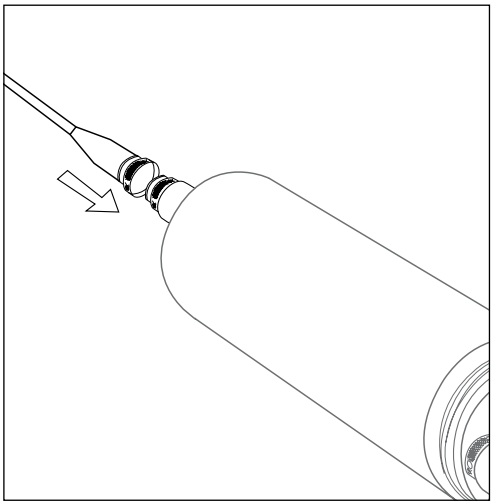
⚠ Make sure there are NO contaminants between the O-ring and the probe. Contaminants will cause leaks when the sonde is deployed.

5. Optical probes (6025 chlorophyll, 6130 Rhodamine, 6131 phycocyanin blue-green algae, 6132 phycoerythrin blue-green algae, 6136 turbidity, and 6150 ROX DO): Insert the probe in the appropriate optical port, seating the pins of the two connectors. Hand-tighten the probe nut to the bulkhead. Finish tightening the probe using the short end of the installation tool. Do not over-tighten.

6. 6562 Rapid Pulse DO, 6560 conductivity/temperature, 6561/6579 pH, or 6565/6569 pH/ORP probes: Insert the probe into the appropriate port, seating the pins of the two connectors. Push the probe inward so that it seats into the port. Screw down the probe nut by hand until it is finger tight. Use the long end of the installation tool to tighten the probe a quarter turn or until snug. Do not over-tighten.

7. Ammonium, nitrate, and chloride ISE probes do not have slip nuts and should be installed without tools. Seat the probe body directly on the sonde bulkhead. Use your fingers to tighten.





Installing Probe Guard

The probe guard protects probes during deployment and some calibration procedures.

Once the probes are installed, screw on the guard by aligning it with the threads on the bulkhead and turn the guard clockwise until secure. Be careful not to bump the 6562 probe membrane when installing the probe guard.

Installing Calibration Cup

Installing the calibration cup is performed in the same manner as installing the probe guard. The calibration/storage cup is used for calibration procedures as well as sonde storage when not in use.

⚠ It is important to calibrate all sensors prior to using the sonde for field measurements. Refer to Section 2.6.2 of the 6-Series User Manual.

Power

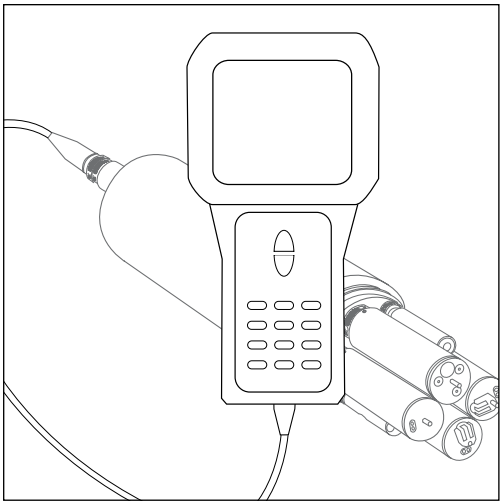
• External power is required for the YSI 600R, 600QS, 600XL, 600XL V2, 6820 V2, and non-battery versions of 600OMS V2 and 600LS sondes.

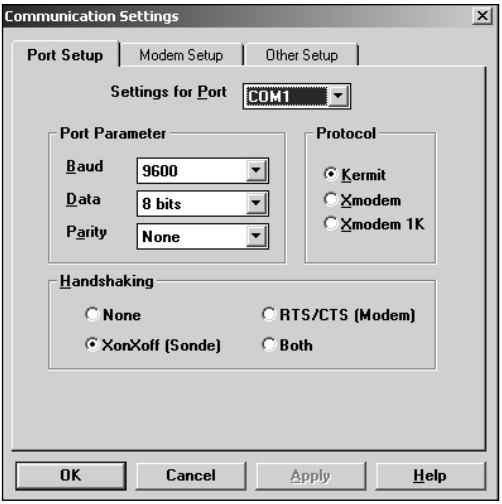
• Internal batteries power the YSI 6920 V2, 6920DW, 6600 V2, 6600EDS V2, 600XLM, 600XLM V2, 600DW, and battery versions of 600OMS V2 and 600LS sondes. These can also run on external power.

• If you have a YSI 650 MDS display or other datalogger, attaching your sonde to it will power the sonde when "power sonde" is enabled.

• For lab calibration, a YSI 6067 or 6095 calibration cable and YSI 6038 (110 VAC) or 6037 (220 VAC) power supply is required for sondes without internal batteries. (6095 cable must be used with a field cable.)

• Connect the 6038 or 6037 power supply to the 6067 or 6095 cable. After attaching the four-pin connector from the power supply to the pigtail, plug the power supply into the appropriate AC outlet.





• When using the sonde's internal batteries, install batteries prior to test and calibration.

• When using the 650 as the interface for sondes with internal power, disable the "sonde power" feature. Conversely, when using the 650 for sondes without batteries, enable the "sonde power" feature.

• Expected power supply outputs are:
6VDC = 4AA
12VDC = 8AA
12VDC = 8C
If you see significantly differing values from these outputs, the batteries may not have a full charge or may be installed incorrectly. (You can find outputs in "Status" in the sonde menu; see next page.)

Refer to Section 2.2 of the 6-Series User Manual for complete details.

Communication

Communication to the sonde is started with EcoWatch® for Windows®, the 650 display/logger, or any terminal emulator.

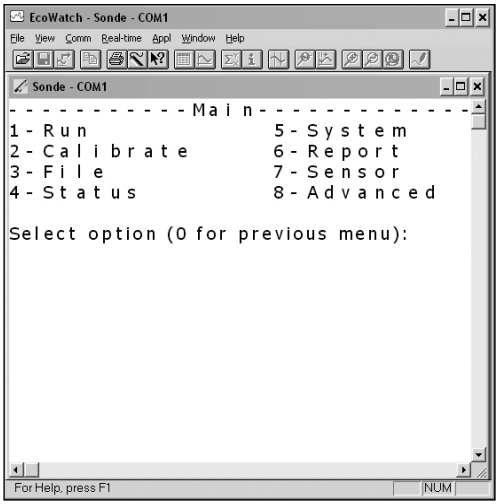
1. Place the EcoWatch compact disk in your computer's CD drive. An Installshield Wizard will automatically start on most computers. Follow the prompts to complete the installation.

2. Select the EcoWatch icon on your desktop or from the Windows Program Menu and open the application.

3. Select the sonde icon in the toolbar, and then select the proper Comm port to which your sonde is connected. Refer to the diagram above for Communication Settings. Click "OK" to open a terminal window.

4. The terminal window is white. Type "Menu" after the # sign, press Enter, and the sonde Main menu will be displayed.

5. This software is menu-driven. Select functions by typing their corresponding numbers. You do not need to press Enter after choosing a selection. Type the 0 or Esc key to return to the previous menu.



6. After establishing connection with EcoWatch, you can configure sonde settings including date/time, sensors, logging, setup, and access stored files.

Refer to Section 4 of the 6-Series User Manual or the Help section of the software.

Menu

Run = set up sonde for discrete or unattended logging applications

Calibrate = access sensors for calibration

File = view logged files including the calibration record (.glp file)

Status = access firmware version, date and time, battery voltage and estimated life, amount of free memory, and logging status

System = access sonde communication settings and instrument identification

Report = choose parameters to log and units of measurement

Sensor = enable sensors and assign probes to ports

Advanced = view calibration constants, choose Auto Sleep configuration, adjust TDS constant and other sonde settings. Refer to Sections 2.5 and 2.9.8 of the 6-Series User Manual before making any changes to the settings in the Advanced Menu.

Technical Support

YSI Technical Support is available Monday through Friday 8 AM to 5 P.M. Eastern Time.

Tel: 800-897-4151 option 1
or +1 937-767-7241 option 1

E-mail: environmental@ysi.com

Web: www.ysi.com

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YSI *incorporated*

6-Series
Multiparameter Water Quality Sondes

User Manual

6-Series:
6600 V2
6600EDS V2
6920 V2
6820 V2
600 OMS V2
600XL
600XLM
600LS
600R
600QS

SAFETY NOTES

TECHNICAL SUPPORT AND WARRANTY INFORMATION

Contact information for technical support and warranty information on YSI's Environmental Monitoring Systems products can be found in **Section 9, Warranty and Service Information**.

COMPLIANCE

When using the YSI 6-Series sondes in a European Community (CE) country, please be aware that electromagnetic compatibility (EMC) performance issues may occur under certain conditions, such as when the sonde is exposed to certain radio frequency fields.

If you are concerned with these issues, consult the Declaration of Conformity that was enclosed with your instrument. Specific conditions where temporary sensor problems may occur are listed in this document.

The Declaration of Conformity for your instrument can be found in Appendix H, EMC Performance. A similar document for YSI Model 650 is located at the end of Section 3, 650 MDS.

SPECIFICATIONS

For general specifications for all YSI Environmental Monitoring Systems products included in this manual, please see **Appendix O, Specifications**.

GENERAL SAFETY CONSIDERATIONS

For Health and Safety issues concerning the use of the calibration solutions with the sondes, please see **Appendix A, Health and Safety**.

NOTICE

Information contained in this manual is subject to change without notice. Effort has been made to make the information contained in this manual complete, accurate, and current. YSI shall not be held responsible for errors or omissions in this operations manual.

WARNING:
When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact, if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

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APPENDIX E TURBIDITY MEASUREMENTS E-1

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SECTION 1 INTRODUCTION

1.1 ABOUT YSI INCORPORATED

From a three-man partnership in the basement of the Antioch College science building in 1948, YSI has grown into a commercial enterprise designing and manufacturing precision measurement sensors and control instruments for users around the world. Although our range of products is broad, we focus on three major markets: water testing and monitoring, health care, and bioprocessing.

In the 1950s, Hardy Trolander and David Case made the first practical electronic thermometer using a thermistor. This equipment was developed to supply Dr. Leland Clark with a highly sensitive and precise temperature sensor for the original heart-lung machine. The collaboration with Dr. Clark has been critical to the success of the company. In the 1960s, YSI refined a Clark invention, the membrane covered polarographic electrode, and commercialized oxygen sensors and meters which revolutionized the way dissolved oxygen was measured in wastewater treatment plants and environmental water. Today, geologists, biologists, environmental enforcement personnel, officials of water utilities and fish farmers recognize us as the leader in dissolved oxygen measurement.

In the 1970s, YSI again worked with Clark to commercialize one of his many inventions, the enzyme membrane. This development resulted in the first practical use of a biosensor, in the form of a membrane based on immobilized glucose oxidase, to measure blood sugar accurately and rapidly. In the next few years, this technology was extended to other enzymes, including lactate oxidase, for applications in biotechnology, health care, and sports medicine.

In the early 1990s, YSI launched a line of multi-parameter water monitoring systems to address the emerging need to measure non-point source pollution. Today we have thousands of instruments in the field that operate with the push of a button, store data in memory, and communicate with computers. These instruments (described in this manual) are ideal for profiling and monitoring water conditions in industrial and wastewater effluents, lakes, rivers, wetlands, estuaries, coastal waters, and monitoring wells. If the instrument has ‘on board’ battery power, it can be left unattended for weeks at a time with measurement parameters sampled at the user’s setup interval and data securely saved in the unit's internal memory. The fast responses of YSI’s sensors make the systems ideal for vertical profiling, and the small size of some our sondes allows them to fit down 2-inch diameter monitoring wells. All of YSI’s multi-parameter systems feature either the YSI-patented Rapid Pulse Dissolved Oxygen Sensor, which exhibits low-stirring dependence and provides accurate results without an expensive, bulky, and power-intensive stirrer or an ROX optical dissolved oxygen sensor which exhibits no flow dependence and is extremely stable in long-term deployments.

YSI has established a worldwide network of selling partners in over 50 countries that includes laboratory supply dealers, manufacturers' representatives, and YSI’s sales force. A subsidiary, YSI UK, distributes products in the United Kingdom, a sales office in Hong Kong supports YSI’s distribution partners in Asia Pacific, and YSI Japan supports distribution partners in Japan.

Through an employee stock ownership plan (ESOP), every employee is one of the owners. In 1994, the ESOP Association named YSI the ESOP Company of the Year. YSI is proud of its products and are committed to meeting or exceeding customers' expectations.

1.2 HOW TO USE THIS MANUAL

The manual is organized to let you quickly understand and operate the YSI 6-Series environmental monitoring systems. However, it cannot be stressed too strongly that informed and safe operation is more than just knowing which buttons to push. An understanding of the principles of operation, calibration

techniques, and system setup is necessary to obtain accurate and meaningful results. Thorough reading and understanding of this manual is essential to proper operation.

Because of the many features, configurations and applications of these versatile products, some sections of this manual may not apply to the specific system you have purchased.

If you have any questions about this product or its application, please contact YSI's Technical Support Group or authorized dealer for assistance. See **Section 9, Warranty and Service Information** for contact information.

1.3 UNPACKING AND INSPECTION

Inspect the outside of the shipping box for damage. If any damage is detected, contact your shipping carrier immediately. Remove the equipment from the shipping box. Some parts or supplies are loose in the shipping box so check the packing material carefully. Check off all of the items on the packing list and inspect all of the assemblies and components for damage.

If any parts are damaged or missing, contact your YSI representative immediately. If you purchased the equipment directly from YSI, or if you do not know from which YSI representative your equipment was purchased, refer to **Section 8, Warranty and Service Information** for contact information.

SECTION 2 SONDES

2.1 GETTING STARTED

The 6-Series Environmental Monitoring Systems from YSI are multi-parameter, water quality measurement, and data collection systems. They are intended for use in research, assessment, and regulatory compliance applications. Section 2 concentrates on sondes and how to operate them during different applications. A sonde is a torpedo-shaped water quality monitoring device that is placed in the water to gather water quality data. Sondes may have multiple probes. Each probe may have one or more sensors that read water quality data.

The following list contains parameters that your sonde may measure. See **Appendix O, Specifications** for the specific parameters of each sonde.

- Rapid Pulse Polarographic Dissolved Oxygen
- ROX Optical Dissolved Oxygen
- Conductivity
- Specific Conductance
- Salinity
- Total Dissolved Solids
- Resistivity
- Temperature
- pH
- ORP
- Depth
- Level
- Flow
- Turbidity
- Chlorophyll
- Rhodamine WT
- Phycocyanin-Containing Blue-green Algae
- Phycoerythrin-Containing Blue-green Algae
- Nitrate-N
- Ammonia-N
- Ammonium-N
- Chloride

This section is designed to quickly familiarize you with the hardware and software components of the sondes and their accessories. You will then proceed to probe installations, cable connections, software installation and finally basic communication with your Sonde. Diagrams, menu flow charts and basic written instructions will guide you through basic hardware and software setup.

2.2 CONNECTING YOUR SONDE

There are a number of ways in which you may connect the sondes to various computers, data collection devices and VT-100 terminal emulators. To utilize the configuration that will work best for your application, make sure that you have all of the components that are necessary. The following list and diagrams (Figures 1-4) are a few possible configurations.

- Sonde to Lab Computer (recommended for initial setup)
- Sonde to Data Collection Platform
- Sonde to Portable Computer
- Sonde to YSI 650 MDS Display/Logger

Figure 1

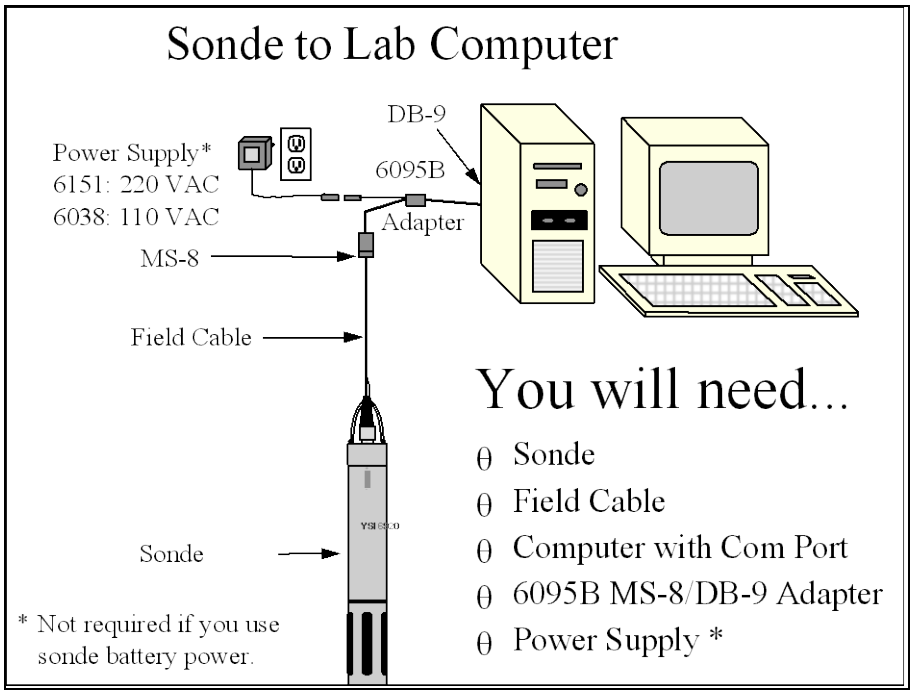


Figure 2

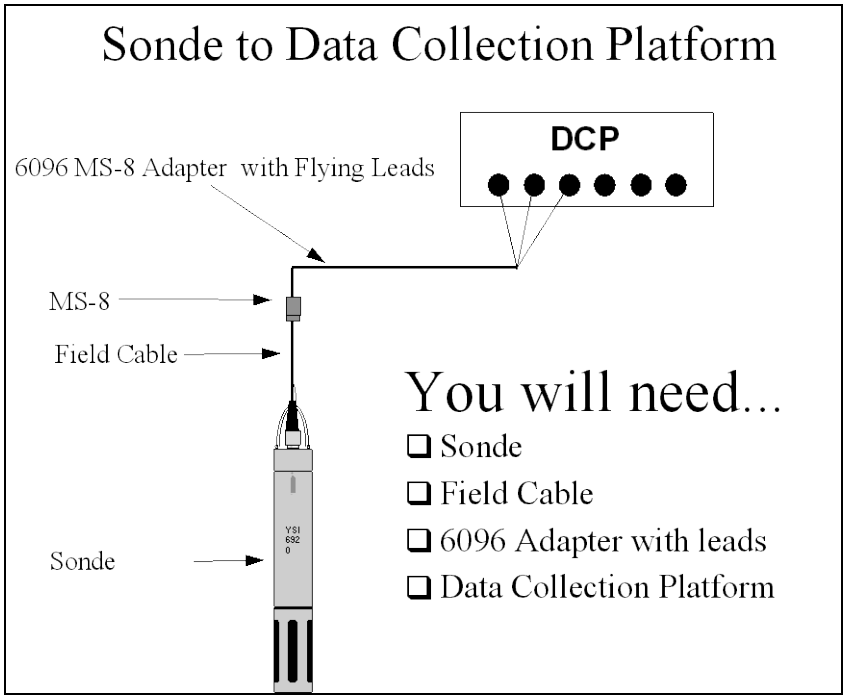


Figure 3

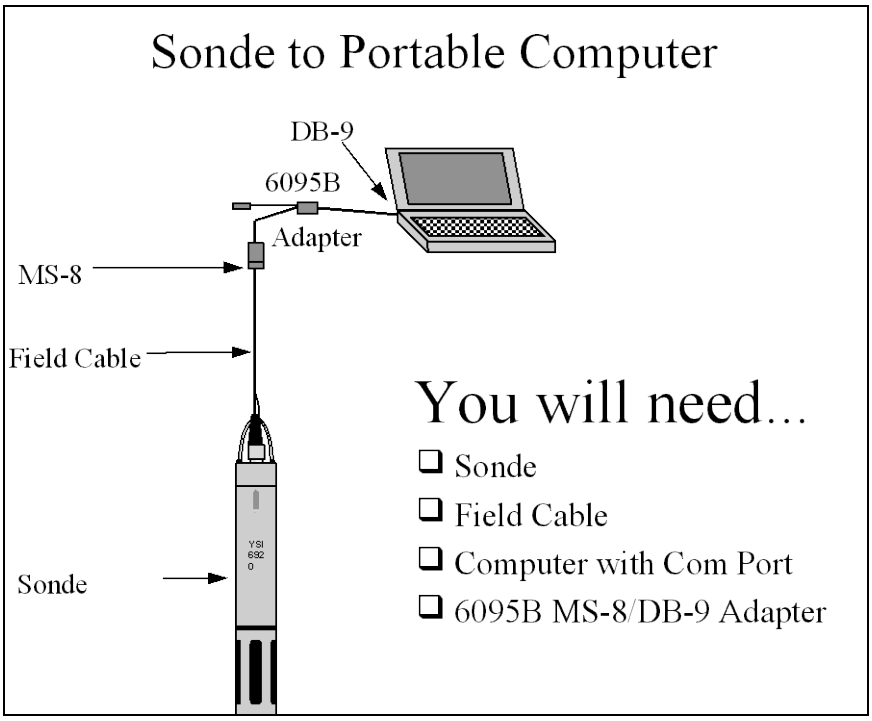
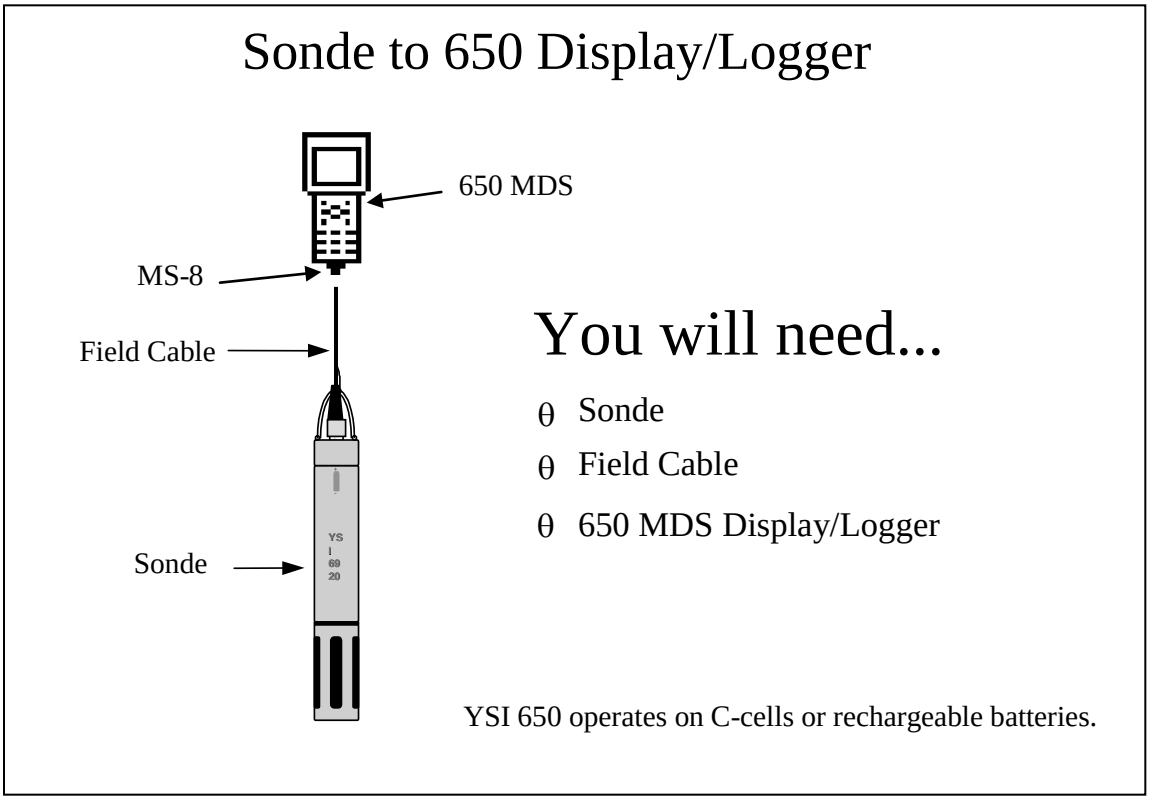


Figure 4


Sonde to 650 Display/Logger
650 MDS
MS-8
Field Cable
Sonde
You will need...
θ Sonde
θ Field Cable
θ 650 MDS Display/Logger
YSI 650 operates on C-cells or rechargeable batteries.

2.3 PREPARING THE SONDE FOR USE

To prepare the sonde for calibration and operation, you need to install probes (sensors) into the connectors on the sonde bulkhead. In addition to probe installation, you need to install a new membrane on the YSI 6562 DO Probe if you are using this item. It is recommended that you install the DO membrane before installing the probe onto the bulkhead. For membrane changes in the future, you may be able to perform this operation without removing the DO probe. This will largely depend on whether the other installed probes interfere with your ability to install a membrane. The next step is providing power for the sondes, through batteries or line power, and then connecting a field cable. The four steps necessary for getting your sonde ready for use are listed below.

Step 1 Installing the Dissolved Oxygen Membrane – Section 2.3.1
Step 2 Installing the Probes – Section 2.3.2
Step 3 Supplying Power – Section 2.3.3
Step 4 Connecting a Field Cable – Section 2.3.4

2.3.1 STEP 1 - INSTALLING THE DISSOLVED OXYGEN MEMBRANE

Note: If you are using a ROX Optical DO sensor for your applications, please skip to Section 2.3.2 at this time.

The 6562 Rapid Pulse Polarographic DO probe is shipped with a protective dry membrane on the sensor tip held in place by an O-ring. Remove the O-ring and membrane. Handle the probe with care. It is very important not to scratch or contaminate the sensor tip. See **Section 2.10.2, Probe Care and Maintenance**, for information on how often the membrane should be replaced.

Unpack the YSI 6562 DO Probe Kit and follow the instructions below.

Open the membrane kit and prepare the electrolyte solution. Dissolve the KCl in the dropper bottle by filling it to the neck with deionized or distilled water and shaking until the solids are fully dissolved. After the KCl is dissolved, wait a few minutes until the solution is free of bubbles.

Figure 5

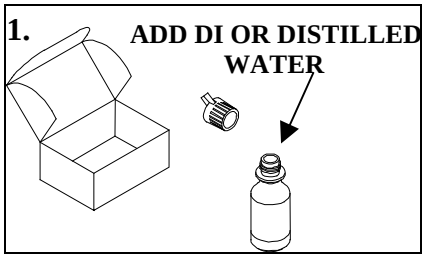
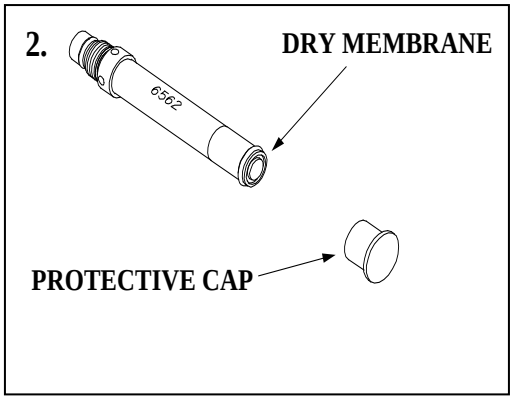


Figure 6



The DO membrane can be installed with the DO probe either free or installed in the sonde. Both methods are described in detail below. **CAUTION: If you install the membrane with the probe not installed in the sonde, be sure that the protective cap is installed on the probe end away from the sensor face to ensure that the connector is not contaminated with electrolyte.**

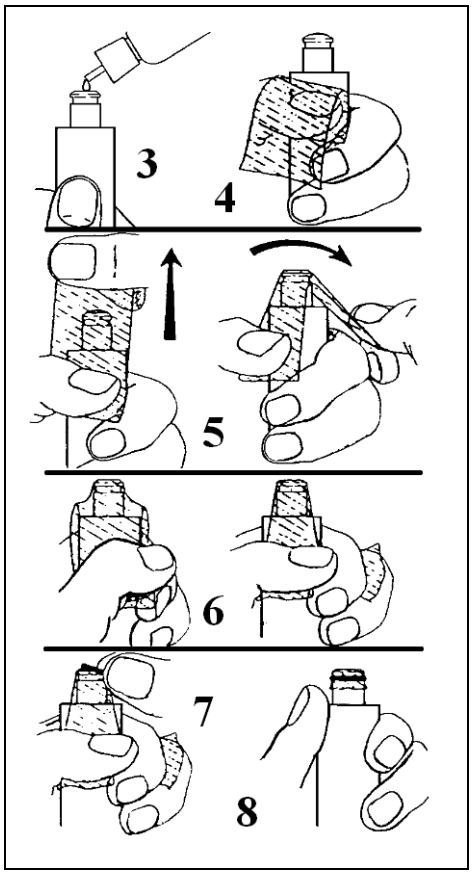
DO MEMBRANE INSTALLATION WITH THE PROBE NOT INSTALLED IN THE SONDE

Remove the protective cap and the dry membrane from the YSI 6562 Dissolved Oxygen probe.

Make sure that the protective cap is installed on the connector end of the probe. Do not allow the electrolyte solution to wet the probe's connector and O-ring seal areas. This solution is extremely corrosive to the connector and is difficult to remove.

Before using any electrolyte, wrap a clean, dry paper towel around the capped probe to catch any spilled electrolyte. Hold the probe in a vertical position and apply a few drops of KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.

Figure 7



Secure a membrane between your left thumb and the probe body. Always handle the membrane with care, touching it only at the ends.

With the thumb and forefinger of your right hand, grasp the free end of the membrane. With one continuous motion, gently stretch it up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.

Secure the end of the membrane under the forefinger of your left hand.

Roll the O-ring over the end of the probe, being careful not to touch the membrane surface with your fingers. There should be no wrinkles or trapped air bubbles. Small wrinkles may be removed by lightly tugging on the edges of the membrane. If bubbles are present, remove the membrane and repeat steps 3-8.

Trim off any excess membrane with a sharp knife or scissors. Rinse off any excess KCl solution, but be careful not to get any water in the connector.

If you are concerned that electrolyte may have dripped onto the O-ring seal area, probe connector, or bulkhead connectors, rub the area clean with paper towels wetted with Deionized water and then dry the affected area with a final dry towel, compressed air blasts, or rinse with fresh alcohol.

NOTE: You may find it more convenient to mount the probe vertically in a vise with rubber jaws while applying the electrolyte and membrane to the sensor tip.

DO MEMBRANE INSTALLATION WITH THE PROBE INSTALLED IN THE SONDE

Secure the sonde in a vertical position using a vise or a clamp and ring stand such that the sensors are upright. Remove the probe guard from the sonde.

Remove the old DO membrane and clean the probe tip with water and lens cleaning tissue. Make sure to remove any debris or deposits from the O-ring groove.

Using the dropper bottle of electrolyte supplied, place electrolyte on the DO probe tip until a high meniscus is formed as shown in Figure 8 below.

Figure 8

Figure 9

Hold the membrane so that all four corners are supported, but do not stretch the membrane laterally.

Position the membrane over the probe, keeping it parallel to the probe face as shown in Figure 9 above.

Using one continuous downward motion, stretch the membrane over the probe face as shown. See Figure 10 below. Do not hesitate to stretch the membrane.

Figure 10

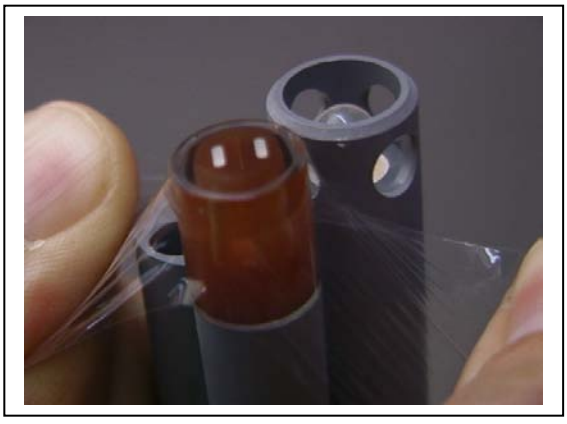


Figure 11

Install a new O-ring by placing one side of the O-ring in the groove and rolling into place across the membrane and into the groove on the opposite side of the probe face. Avoid touching the probe face with

your fingers. Once the O-ring is in position, squeeze it every 90 degrees to equalize the tension. See Figure 11 above. DO **NOT** USE GREASE OR LUBICANT OF ANY KIND ON THE O-RING.

Using a hobby knife or a scalpel, trim the excess Teflon from the membrane, making your cut about 1/8 inch below the O-ring as shown in Figure 12 below. A razor blade can be used for the cut if no knife or scalpel is available.

Figure 12

Figure 13

If the installation has been done properly, the finished product should have no bubbles, wrinkles, or tears as shown in Figure 13 above.

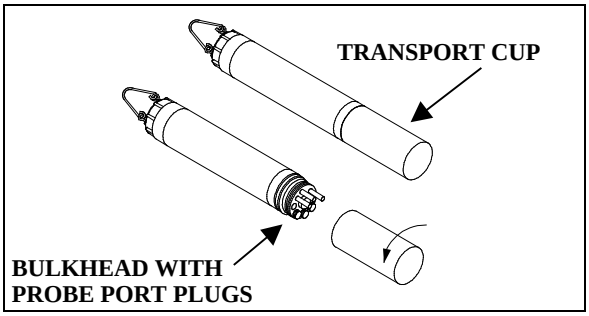
NOTE: Observe the following cautions to assure that your membrane installation is proper:

- Secure the sonde tightly so that it will not move during membrane installation.
- Wash hands before installation and do not allow finger oils or O-ring lubricant to touch the probe face or the membrane.
- Use caution when replacing the probe guard that you do not touch the membrane. If you suspect that the membrane has been damaged, replace it immediately.

2.3.2 STEP 2 - INSTALLING THE PROBES

Remove the calibration cup from your sonde by hand as shown in Figure 14, to expose the bulkhead.

Figure 14



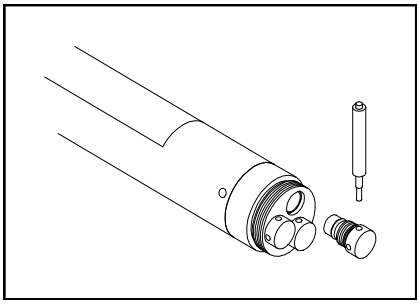
REMOVING THE PORT PLUGS

Using the long extended end of the probe installation tool supplied in the YSI 6570 Maintenance Kit, remove the port plugs. Save all the port plugs for possible future use.

There are a variety of probe options for the sondes. Figures 15, 16 and 17 illustrate the uses of the common tool for port plug removal. Note that this tool will also be used to install the various probes.

If the tool is misplaced or lost, you may use 7/64" and 9/64" hex keys as substitutes.

Figure 15



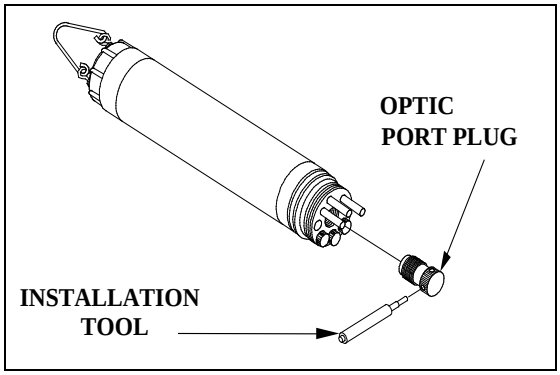


Figure 16

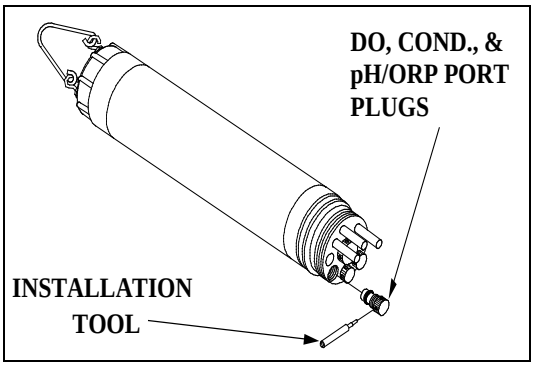
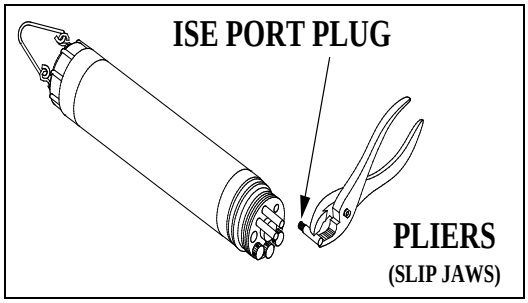


Figure 17

NOTE: You may need pliers to remove the ISE port plugs, but do not use pliers to tighten the ISE probes. Hand-tighten only.

Now refer to Figures 19-24 to find the probe locations in your sonde.

Figure 18

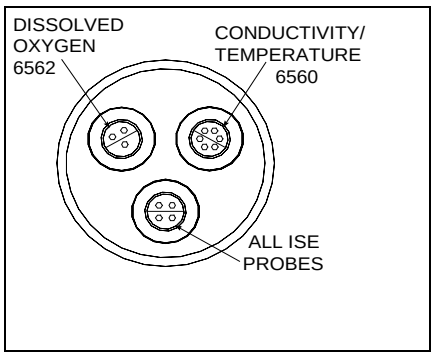


600XL & 600XLM SONDE BULKHEAD

3 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, and 1 pH/ORP

- ❑ 6562 Dissolved oxygen probe = 3-pin connector
- ❑ 6560 Conductivity/Temperature = 6-pin connector
- ❑ 6561 pH probe = 4 pin connector
- ❑ 6565 Combo pH/ORP probe = 4 pin connector

Figure 19

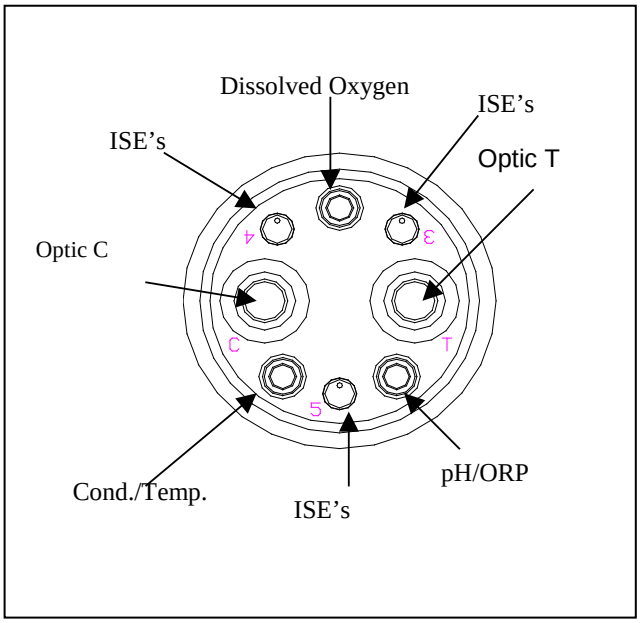


6600V2-2 SONDE BULKHEAD

8 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 2 Optical, 3 ISE, 1 pH/ORP

- ❑ 6562 Dissolved oxygen probe = 3-pin connector
- ❑ 6560 Conductivity/Temperature = 6-pin connector
- ❑ 6561 or 6561FG pH probe = 4 pin connector
- ❑ 6565 or 6565FG pH/ORP probe = 4 pin connector
- ❑ 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- ❑ 6882 Chloride Probe = leaf spring connector
- ❑ 6883 Ammonium Probe = leaf spring connector
- ❑ 6884 Nitrate Probe = leaf spring connector
- ❑ 6026 Turbidity Probe, Wiping = 8 pin connector
- ❑ 6136 Turbidity Probe, Wiping = 8 pin connector
- ❑ 6025 Chlorophyll Probe, Wiping = 8 pin connector
- ❑ 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- ❑ 6150 Optical Dissolved oxygen probe = 8 pin connector
- ❑ 6131 PC-Blue-green Algae probe = 8 pin connector
- ❑ 6132 PE-Blue-green Algae probe = 8 pin connector

Figure 20A

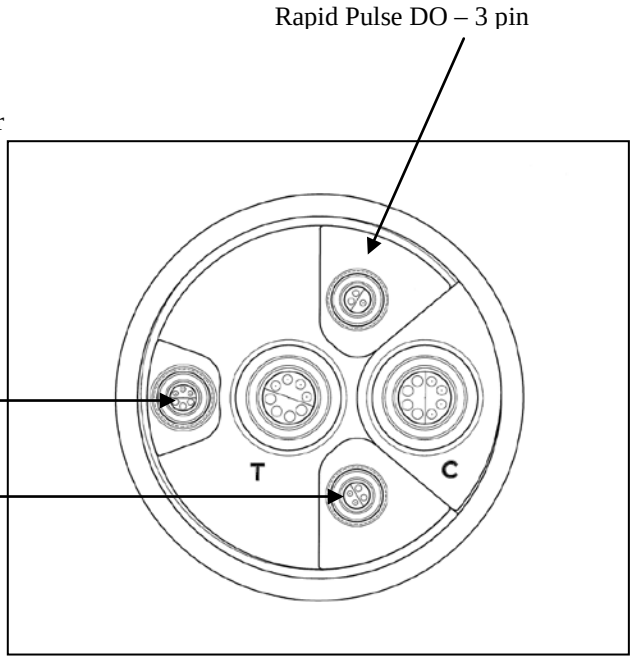


6600EDS V2-2 SONDE BULKHEAD

5 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 2 Optical, 1 pH/ORP

Figure 20B

- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

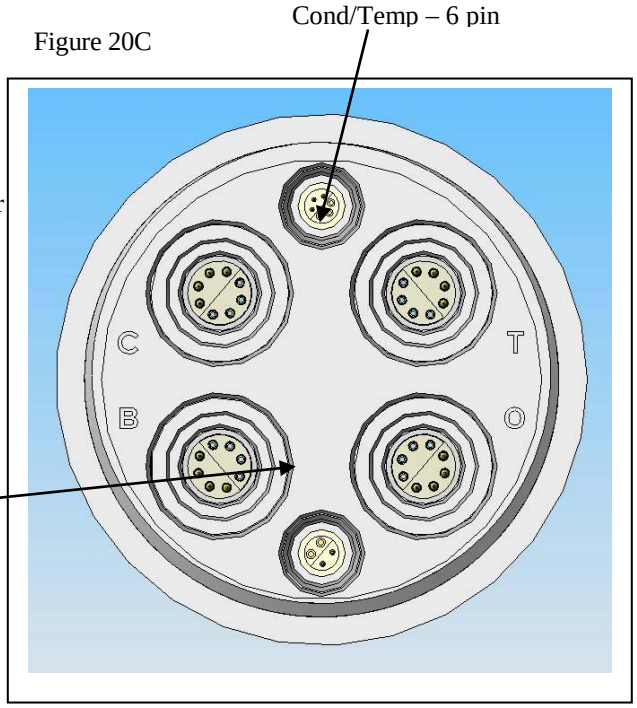


6600V2-4 SONDE BULKHEAD

6 Port Sonde: 1 Conductivity/Temperature, 4 Optical, 1 pH/ORP

Figure 20C

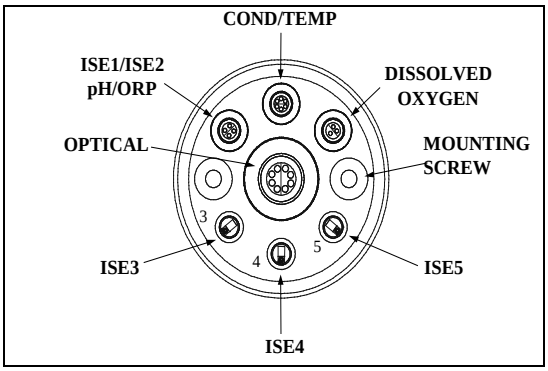
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
- 6566 Fouling Resistant pH/ORP probe = 4 pin connector
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector



6820V2-1 & 6920V2-1 SONDE BULKHEADS

7 Port Sonde: 1 Rapid Pulse DO, 1 Conductivity/Temperature, 1 Optical, 1 pH/ORP, 3 ISE

Figure 21A



- 6562 Dissolved oxygen probe = 3-pin connector
- 6560 Conductivity/Temperature = 6-pin connector
- 6561 or 6561FG pH probe = 4 pin connector
- 6565 or 6565FG pH/ORP probe = 4 pin connector
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- 6882 Chloride Probe = leaf spring connector
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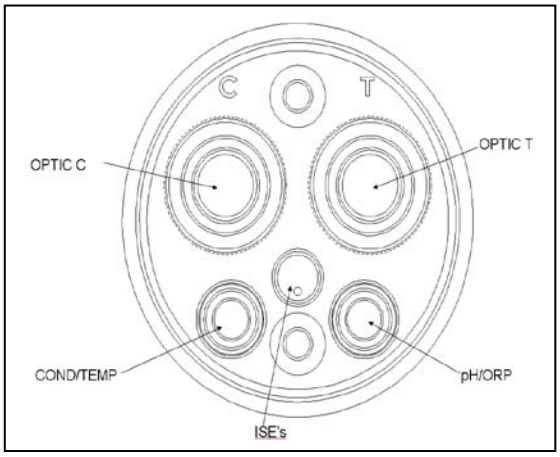
- 6026 Turbidity Probe, Wiping = 8 pin connector
- 6136 Turbidity Probe, Wiping = 8 pin connector
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

6820V2-2 & 6920V2-2 SONDE BULKHEADS

5 Port Sonde: 1 Conductivity/Temperature, 2 Optical, 1 pH/ORP, 1 ISE

Figure 21B



- 6560 Conductivity/Temperature = 6-pin connector
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- 6565 or 6565FG pH/ORP probe = 4 pin connector
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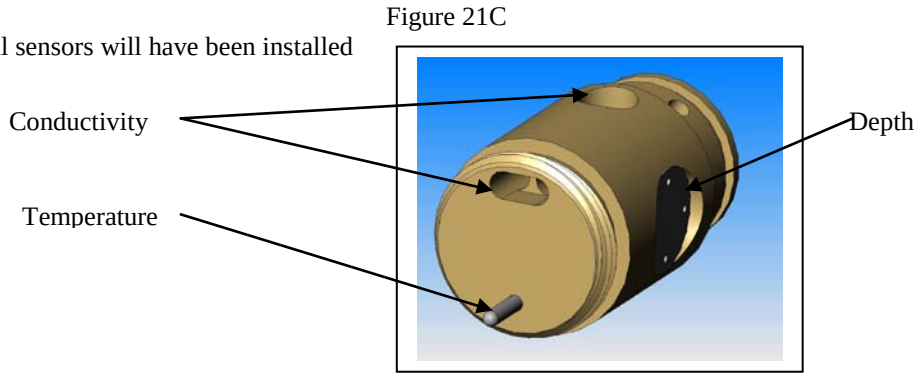
- 6025 Chlorophyll Probe, Wiping = 8 pin connector
- 6130 Rhodamine WT Probe, Wiping = 8 pin connector
- 6150 Optical Dissolved oxygen probe = 8 pin connector
- 6131 PC-Blue-green Algae probe = 8 pin connector
- 6132 PE-Blue-green Algae probe = 8 pin connector

600LS BULKHEAD

If are working with a 600LS, all sensors will have been installed at the factory.

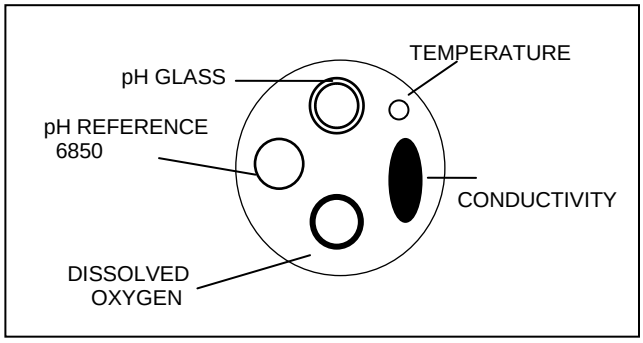
Figure 21C



600R BULKHEAD

If are working with a 600R sonde, your instrument will arrive with the probes installed.

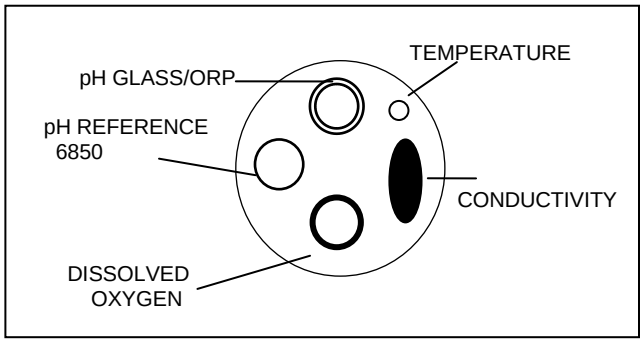
Figure 22



600QS BULKHEAD

If are working with a 600QS sonde, your instrument will arrive with the probes installed.

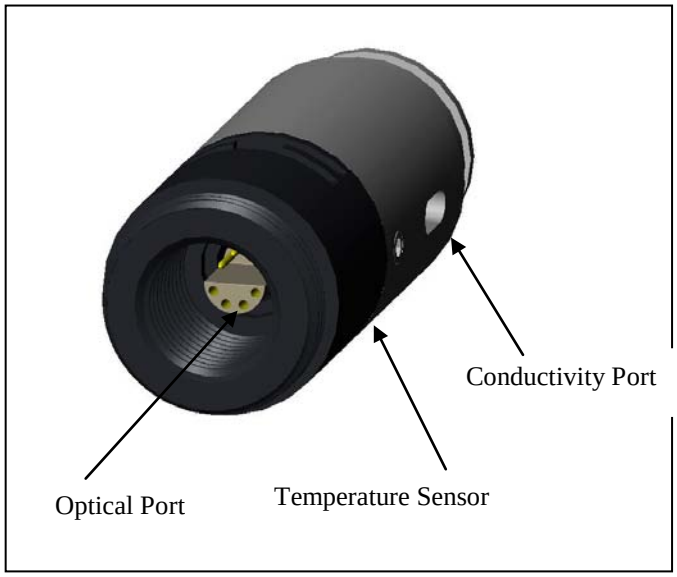
Figure 23



600 OMS V2-1 BULKHEAD

The conductivity sensor (module/port) for the 600 OMS V2-1 is factory installed. Optical probes (turbidity, chlorophyll, rhodamine WT, ROX optical DO, BGA-PC, and BGA-PE) are threaded into the optical port on the bottom of the sonde by the user.

Figure 24

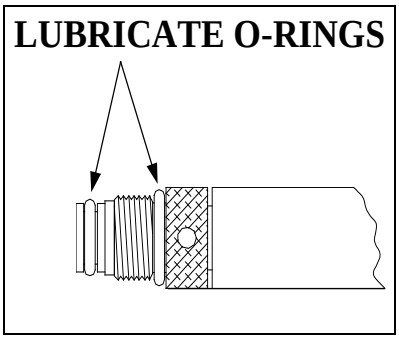


LUBRICATE O-RINGS

Apply a thin coat of O-ring lubricant, supplied in the YSI 6570 Maintenance Kit, to the O-rings on the connector side of each probe that is to be installed.

CAUTION: **Make sure that there are NO contaminants between the O-ring and the probe. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Figure 25



NOTE: Before installing any probe into the sonde bulkhead, be sure that the probe port is free of moisture. If there is moisture present, you may use a can of compressed air to blow out the remaining moisture.

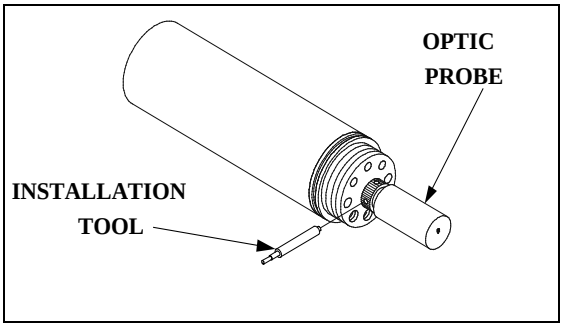
INSTALLING THE TURBIDITY, CHLOROPHYLL, RHODAMINE WT , BGA-PHYCOCYANIN, BGA-PHYCOERYTHRIN, AND ROX OPTICAL DISSOLVED OXYGEN PROBES

If you are using any of optical probes listed, it is recommended that the optical sensors be installed first. If you are not installing one of these probes, do not remove the port plug, and go on to the next probe installation.

All optical probes, 6136 turbidity, 6025 chlorophyll, 6130 Rhodamine WT, 6131 Phycocyanin Blue-green algae, 6132 Phycoerythrin-Blue-green algae, and 6150 ROX Optical DO are installed in the same way. Install the probe into the center port, seating the pins of the two connectors before you begin to tighten. Tighten the probe nut to the bulkhead using the short extended end of the tool supplied with the probe. Do not over-tighten.

CAUTION: Be careful not to cross-thread the probe nut.

Figure 26



The YSI 6820V2-1 and 6920V2-1 sondes can accept a single turbidity, chlorophyll, Rhodamine WT, BGA-PC, BGA-PE, or ROX DO probe. The 6600V2-2, 6600EDS V2-2, 6820V2-2, and 6920V2-2 sondes can accept and utilize two of the six optical sensors at the same time. The two optical ports of these sondes are labeled "T" and "C" on the sonde bulkhead. Each port can accept any of the six sensors so be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly. The 6600V2-4 sonde can accept and utilize four of the six optical sensors at the same time. The four optical ports of this sonde are labeled "T" , "C", "B", and "O" on the sonde bulkhead. Each port can accept any of the six sensors so be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly.

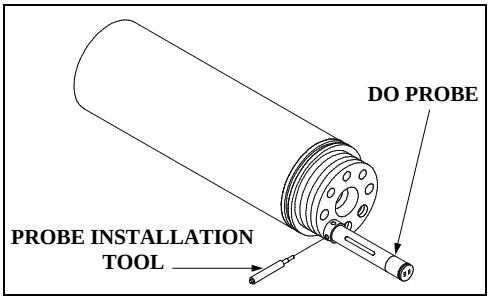
INSTALLING THE 6562 RAPID PULSE DISSOLVED OXYGEN PROBE, CONDUCTIVITY/TEMP AND pH/ORP PROBES

Insert the probe into the correct port and gently rotate the probe until the two connectors align.

The probes have slip nuts that require a small probe installation tool to tighten the probe. With the connectors aligned, screw down the probe nut using the long extended end of the probe installation tool. Do not over-tighten.

CAUTION: Do not cross thread the probe nut.

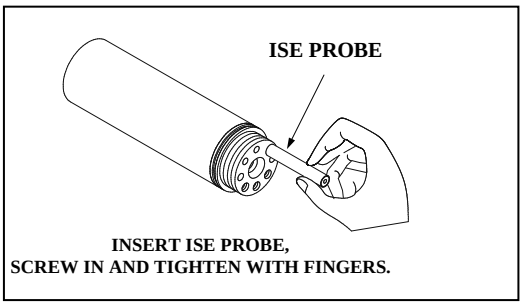
Figure 27



INSTALLING THE ISE PROBES

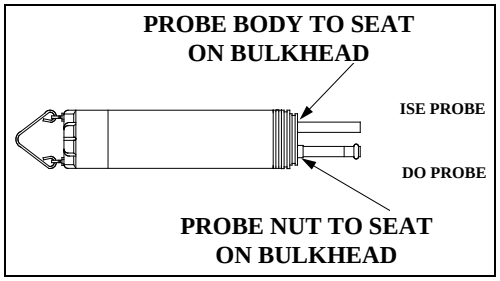
The Ammonium, Nitrate and Chloride ISE probes do not have slip nuts and should be installed without tools. Use only your fingers to tighten. Any ISE probe can be installed in any of the three ports labeled "3", "4", and "5" on the sonde bulkhead of the 6820V2-1, 6920V2-1, and 6600V2-2 sondes or the single ISE port on the 6820V2-2 and 6920V2-2 bulkheads. Be sure to remember which sensor was installed in which port so that you will later be able to set up the sonde software correctly.

Figure 28



IMPORTANT: Make sure that the probe nut or probe body of the ISE probes are seated directly on the sonde bulkhead. This will ensure that connector seals will not allow leakage.

Figure 29



INSTALLING THE PROBE GUARD

Included with each sonde is a probe guard. The probe guard protects the probes during calibration and measurement procedures. Once the probes are installed, install this guard by aligning it with the threads on the bulkhead and turn the guard clockwise until secure.

CAUTION: Be careful not to damage the Rapid Pulse DO membrane during installation of the probe guard.

Figure 30 shows the YSI 6820V2-1/6820V2-2/6920V2-1/6920V2-2 probe guard; the guard for the 6600V2-2/6600V2-4 is similar. The YSI 600R, 600QS, 600XL and 600XLM probe guards resemble Figure 31.

Figure 30

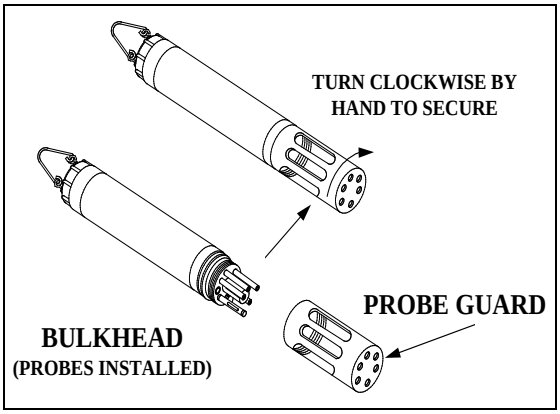
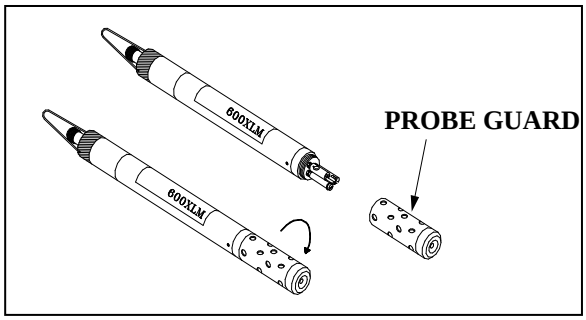


Figure 31



2.3.3 STEP 3 - POWER

Some type of external power supply is required to power the YSI 600R, 600QS, 600XL 6820V2-1, and the non-battery version of the 600 OMS V2-1sondes. The YSI 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, 600XLM, and battery version of the 600 OMS V2-1sondes have internal batteries or can run on external power.

If you have purchased a YSI 650 MDS display/logger, attaching your sonde to the display/logger will allow your sonde to be powered from the batteries or the external power of the display/logger. See **Section 3, Displays/Loggers,** for power options.

The battery-powered version of this instrument is powered by alkaline batteries, which the user must remove and dispose of when the batteries no longer power the instrument. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in this instrument contains a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized YSI service center will remove this battery and properly dispose of it, per service and repair policies.

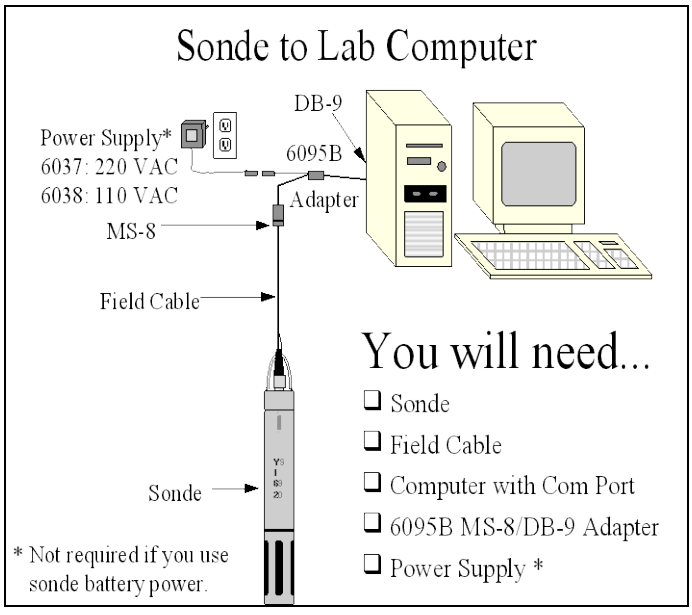
POWER FOR LAB CALIBRATION

A YSI 6038 (110 VAC) or 6651 (64-240 VAC) Power Supply is required for sondes without internal batteries when using them with a PC for calibration and setup. Sondes with internal batteries do not require a power supply, but using the sonde with a power supply in the lab is often convenient and extends battery life. Most adapters include a short pigtail for power that plugs into the power supply. After attaching the four-pin connector from the power supply to the pigtail, simply plug the power supply into the appropriate AC outlet.

See **Section 2.2, Connecting Your Sonde**, for specific information on cables, adapters and power supplies required for connecting your sonde to various devices.

The system configuration best suited for initial setup is shown in Figure 32.

Figure 32



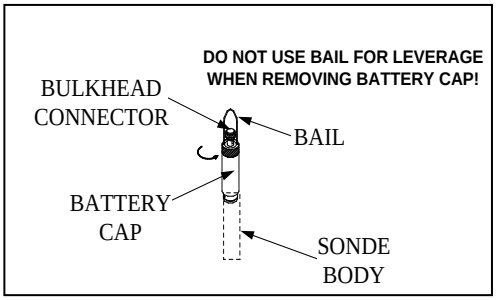
INSTALLING BATTERIES

The 600XLM, 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2 and battery version of the 600 OMS V2-1are the sondes that use alkaline batteries for power. A set of batteries is supplied with each of these sondes. If you do not have one of these sonde model types, you may skip this section.

INSTALLING BATTERIES INTO THE YSI 600XLM OR 600 OMS V2-1 SONDES

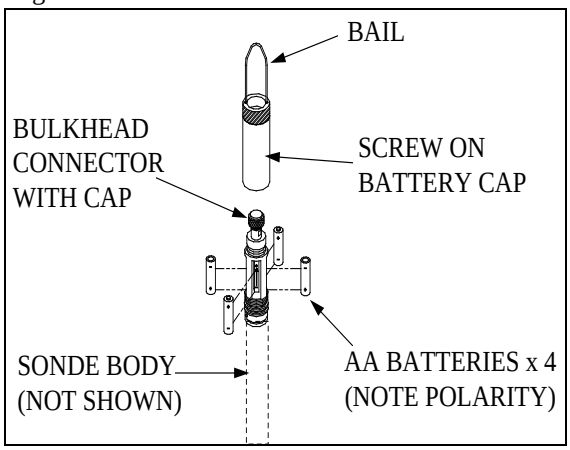
To install 4 AA-size alkaline batteries into the sonde, refer to the following directions and Figure 33.

Figure 33



Grasp the cylindrical battery cover and unscrew by hand. Then slide the battery lid up and over the bulkhead connector. Insert batteries, paying special attention to polarity. Labeling on the battery compartment posts describes the orientation. It is usually easiest to insert the negative end of battery first and then "pop" the positive terminal into place.

Figure 34



Check the O-ring and sealing surfaces for any contaminants that could interfere with the O-ring seal of the battery chamber.

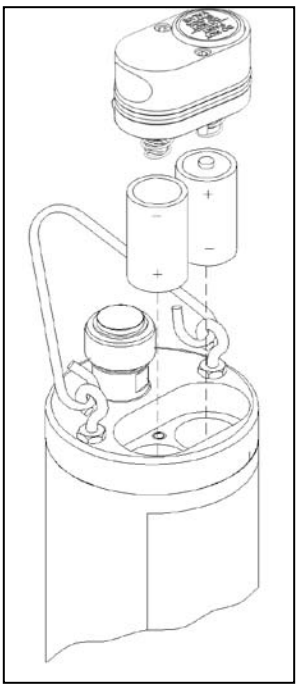
CAUTION: **Make sure that there are NO contaminants between the O-ring and the sonde. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Lightly lubricate the o-ring on the outside of the battery cover. DO NOT lubricate the internal o-ring.

Return the battery lid and tighten by hand.
DO NOT OVER-TIGHTEN.

INSTALLING BATTERIES INTO THE YSI 6600V2-2, 6600EDS V2-2, AND 6600V2-4 SONDES

Figure 35



IMPORTANT SAFETY FEATURE: The 116003 battery lid for the 6600V2-2, 6600EDS V2-2, and 6600V2-4 is equipped with a safety pressure-release valve. The valve will vent off any pressure build up in the battery compartment from waste gas that could be created by battery failure, improperly marked or installed batteries, flooding, and dead or heavily discharged batteries. Pressure from the waste gas can deform the battery compartment and cause the sonde to shatter, projecting fragments from the sonde casing in all directions. People near a sonde that shatters could suffer serious puncture wounds and serious eye injuries. DO NOT defeat this safety feature by blocking the valve or painting over or in close proximity to the valve. DO NOT attempt to disassemble the safety valve.

Install 8 C-size alkaline batteries according to the following directions and Figure 35.

Using the 9/64" hex driver supplied with the 6600V2-2, 6600EDS V2-2 and 6600V2-4 loosen the battery lid screws.

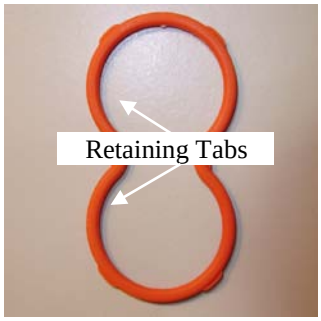
NOTE: The battery lid screws are captive. It is not necessary to remove them from the lid completely.

Remove the battery lid and install the batteries, as shown. If installing or replacing the batteries, test batteries for proper polarity and voltage and observe the correct polarity before installing the batteries into the battery chamber.

***CAUTION*: Be sure the orange O-ring is installed in the groove of the lid. The o-ring is designed with retention tabs to prevent it from falling out of the grove during installation. Check the O-ring and sealing surfaces for any contaminates which could interfere with the O-ring seal of the battery chamber. Remove any contaminates present. Also clean the protective O-rings which are located the side of the battery lid. Apply a small amount of grease to the threads of each screw to prevent binding. See the next section and Figures 35A through 35L for details on proper installation of the battery lid o-ring.**

The updated face seal for the 6600 sonde battery lid incorporates six retaining tabs to hold the face seal in the seal groove during installation, allowing consistent and effective sealing after battery replacement. In order for this feature to work properly, the retaining tabs must be correctly seated in the battery lid's seal groove to prevent it from becoming dislodged during handling. If the seal is not installed correctly it can fall out of its groove during battery lid installation and then can be crushed during assembly. This may cause damage to the seal and cause battery compartment flooding when the sonde is deployed. The following procedure is a recommended method to properly retain the seal in its groove:

1. Place seal on the battery lid groove so that it follows the profile of the groove and is centered about the two middle retaining tabs.



Figures 35A and 35B

2. Press two of the outermost retaining tabs down into the groove. It should be clear that the retaining tabs have recessed into the groove along with the seal so that the tabs outermost edges are at or below the battery lid's mounting surface.

Figures 35C and 35D

3. Press the remaining two outermost retaining tabs into the groove and check to make sure the tabs have been recessed as before. Verify that the other two previously seated retaining tabs have not been forced from their position in the groove.

Figures 35E and 35F

4. Place your thumbs on the seal about a ¼" or so from the sides of the center retaining tab and press the seal down into the groove while sliding your thumbs towards each other. This stretches the seal to fit the profile of the groove allowing the center tab to be seated properly. You may need to use the tip of one of your thumbs to finish pressing the tab into place.

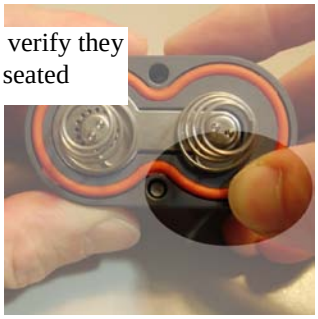
Figures 35G and 35H

5. Press the remaining middle retaining tab into the groove as before and verify that none of the other retaining tabs have been forced from their positions in the groove during this part of the seal installation.

Figures 35I and 35J

6. To ensure that all the retaining tabs are properly seated in the seal groove you can apply pressure to the seal forcing it into the groove at the location of each tab. This will further seat each tab into the groove allowing it to capture the seal.

Figures 35K and 35L



***CAUTION:* Before installing the battery lid, ensure that the pressure release valve is closed. If the pressure release valve is open, DO NOT install (see Figures 35M and 35N). The valve cannot be reset and the battery lid must be replaced before sonde deployment. Contact YSI Technical Support for instructions.**

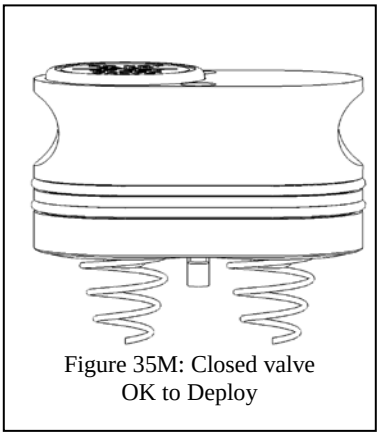


Figure 35M: Closed valve
OK to Deploy

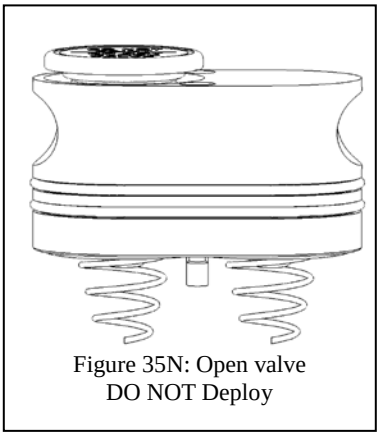


Figure 35N: Open valve
DO NOT Deploy

Lightly lubricate the o-rings on the outside of the battery cover. DO NOT lubricate the orange internal o-ring.

Return the battery lid and HAND tighten the screws with the hex driver until snug. *DO NOT OVER TIGHTEN.*

***CAUTION*: Over-tightening the screws may cause the battery compartment to flood. Do NOT use power tools to tighten the battery lid screws.**

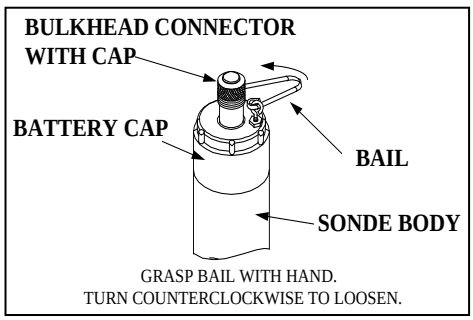
With the battery cover installed and secured, check the battery voltage in the sondes Status Menu. The voltage must be 12.0 volts or higher with new cells. A voltage less then 12.0 volts could indicate that a cell was installed upside down or that one of the cells is not at full strength.

***CAUTION: Remove Batteries When Not in Use.* As with any battery-powered instrumentation, batteries should be removed before short or long-term storage. Even with the new battery lid, batteries can leak, releasing toxic and corrosive battery acid and damaging equipment.**

INSTALLING BATTERIES IN THE 6920V2-1 AND 6920V2-2 SONDES

To install the 8 AA-size alkaline batteries into the sonde, refer to the following directions and Figures 36 and 37.

Figure 36



Position the bail so that it is perpendicular to the sonde and use it as a lever to unscrew the battery cap by hand. Then slide the battery lid up and over the bulkhead connector.

Insert batteries, paying special attention to polarity. Labeling on the top of the sonde body describes the orientation.

Check the O-rings and sealing surfaces for any contaminants that could interfere with the seal of the battery chamber.

***CAUTION:* Make sure that there are NO contaminants between the O-ring and the sonde. Contaminants that are present under the O-ring may cause the O-ring to leak when the sonde is deployed.**

Lightly lubricate the o-rings on the bottom of the threads and on the connector stem as shown in Figure 37.

Return the battery lid and tighten by hand. *DO NOT OVER-TIGHTEN.*

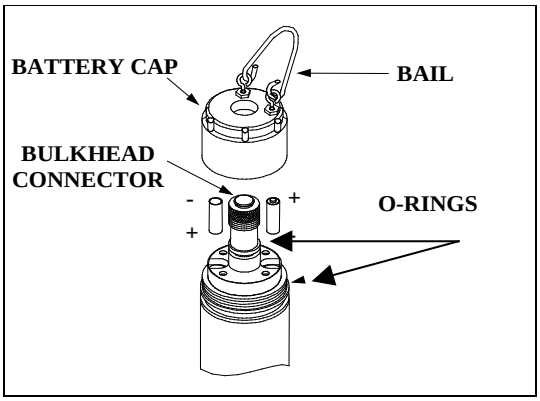


Figure 37

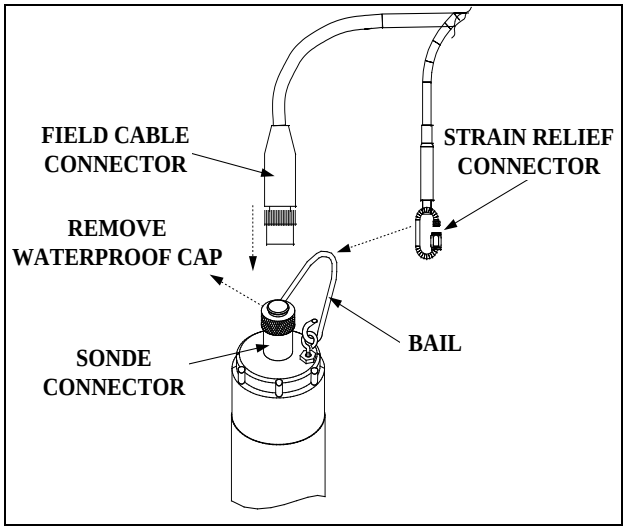
2.3.4 STEP 4 - CONNECTING A FIELD CABLE

Figure 38

All YSI 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2, 6820V2-2, 600XLM, 600QS, and 600 OMS V2-1sondes have a sonde-mounted cable connector for attachment of the field cable. Some versions of the 600R, 600XL, and 6820V2-1 sondes also have this connector.

However, some versions of the YSI 600R, 600XL, and 6820V2-1sondes have permanently attached "integral" cables. If your sonde has a cable that is non-detachable, the next section will not be relevant.

To attach a field cable to the sonde connector, remove the waterproof cap from the sonde connector and set it aside for later reassembly during deployment or storage. Then connect your field cable to the sonde connector.



A built-in "key" will ensure proper pin alignment. Rotate the cable gently until the "key" engages and then tighten the connectors together by rotating clockwise. Attach the strain relief connector to the sonde bail. Rotate the strain relief connector nut to close the connector's opening.

For all of the sondes, the other end of the cable is a military-style 8-pin connector (MS-8). Through use of a YSI 6095B MS-8 to DB-9 adapter, the sonde may be connected to a computer for setup, calibration, real-time measurement, and uploading files.

This MS-8 connector also plugs directly into the 650 MDS display/logger. This instrument contains a microcomputer that allows it to be used in a similar manner to that of a terminal interface to a PC.

As an alternative to the field cable, you may use a YSI 6067B calibration cable for laboratory interaction with the sonde. In this case, simply plug the proper end of the cable into the sonde connector and attach the DB-9 connector of the cable to the Com port of your computer.

CAUTION: The 6067B cable is for laboratory use only -- it is not waterproof and should not be submersed!

Sondes that are equipped with level sensors use vented cables. See **Appendix G, Using Vented Level**, for detailed information.

2.4 ECOWATCH FOR WINDOWS -GETTING STARTED

This section will describe how to get started with EcoWatch for Windows, but detailed information is provided in **Section 4, EcoWatch for Windows**, or a convenient Windows Help section that is part of the software. It is recommended that you thoroughly read Section 4 or use the Help function for a comprehensive understanding of EcoWatch for Windows.

2.4.1 INSTALLING ECOWATCH FOR WINDOWS

EcoWatch for Windows software must be used with an IBM-compatible PC with a 386 (or better) processor. The computer should also have at least 4MB of RAM and Windows Version 3.1 or later.

Place the EcoWatch for Windows compact disk in your CD ROM drive. Select **Start**, then **Run** and type **d:\setup.exe** at the prompt. Press **Enter** or click on "**OK**" and the display will indicate that EcoWatch is proceeding with the setup routine. Simply follow the instructions on the screen as the installation proceeds.

2.4.2 RUNNING ECOWATCH FOR WINDOWS

To run EcoWatch for Windows, simply select the EcoWatch icon on your desktop or from the Windows Program Menu. For help with the EcoWatch program, see **Section 4, EcoWatch** or use the Help section of the software.

2.4.3 ECOWATCH FOR WINDOWS SETUP

To setup the EcoWatch software for use with a sonde, select the sonde icon on the toolbar, and then the **proper** Com port to which your sonde is connected. If the default setting is correct, it does not need to be changed. Click "**OK**" to open a terminal window.

From the **Comm** Menu, select the **Settings** option to check the baud rate. The baud rate should be 9600. If it is not, select 9600 from the list and press **Enter**.

From the **Settings** Menu, select the **Font/Color** and **Background Color** options to choose a color scheme for the EcoWatch for Windows menus.

2.5 SONDE SOFTWARE SETUP

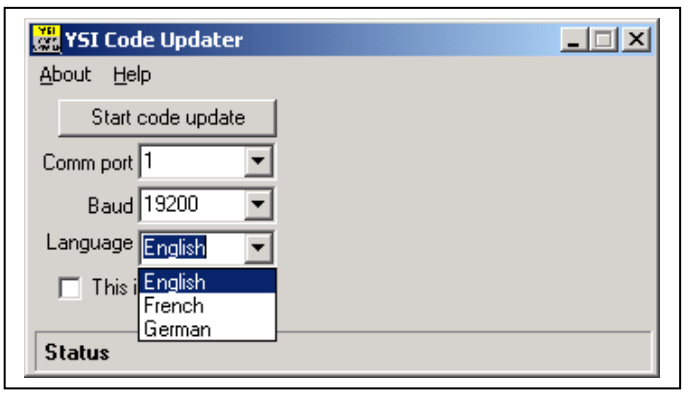
There are two sets of software at work in any YSI environmental monitoring system. One is resident in your PC and is called EcoWatch for Windows. The other software is resident in the sonde itself. In this section, you will first make sure that the language associated with your sonde software is appropriate to your application and change it if necessary. You will set up the sonde software using EcoWatch for Windows as the interface device between the sonde and your PC.

SETTING UP THE SONDE SOFTWARE LANGUAGE

The menus in the sonde software can be viewed in English, German, or French. However, the choice of language CANNOT be made from the sonde software itself. Rather the choice must be selected via a complete update of the software itself from the YSI Website as described below. Note that the menus in your sonde will be shown in English when you receive the instrument and, if this is your language of choice, no further action is required and you should skip to the next section. If you wish to change the language of your menus to German or French, use the following instructions.

Follow the step-by-step instructions below to change the language for the menus in your 6-series sonde:

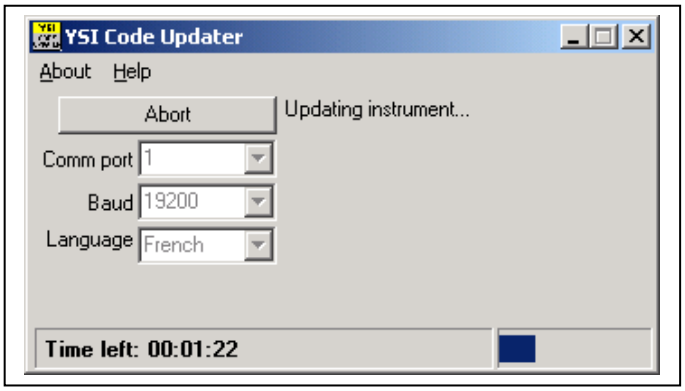
- Connect your sonde to the serial port of a PC with access to the Internet using the proper cable as described in the previous section of this manual.
- Make sure that the sonde is powered with either internal batteries or a suitable power supply.
- Access the YSI Environmental Software Downloads page at www.ysi.com/edownloads or go to main page at www.ysi.com and click on Support button in green bar.
- Log in, or if a first time user, fill out the registration form and wait for a login password via return E-mail.
- Click on the **Software** folder under the Software Downloads section.
- Inside the folder, click on the file *6-Series & 556MPS Code Updater, M-DD-YYYY* and save the file to a temporary directory on your computer.
- After the download is complete, run the file that you just downloaded and follow the on-screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI Technical Support for advice.
- Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:



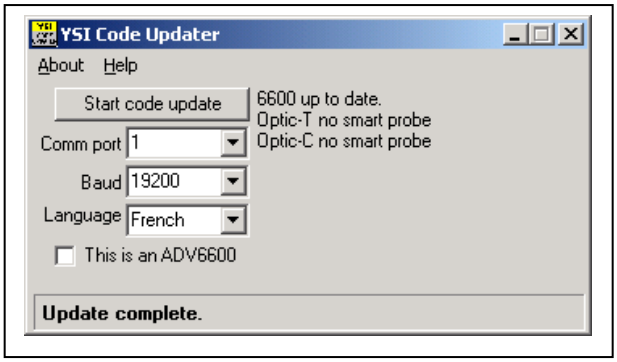
- Set the Comm port number to match the port to which you connected the sonde cable and make sure that the “This is an ADV6600” selection is NOT checked.

- **NEXT, SELECT THE LANGUAGE (ENGLISH, FRENCH, OR GERMAN) WHICH WILL BE USED IN YOUR SONDE MENUS.**

- Then click on the Start Code Update button. An indicator bar will show the progress of the upgrade as shown below.



- When the update is finished (indicated on the PC screen as shown below), close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.



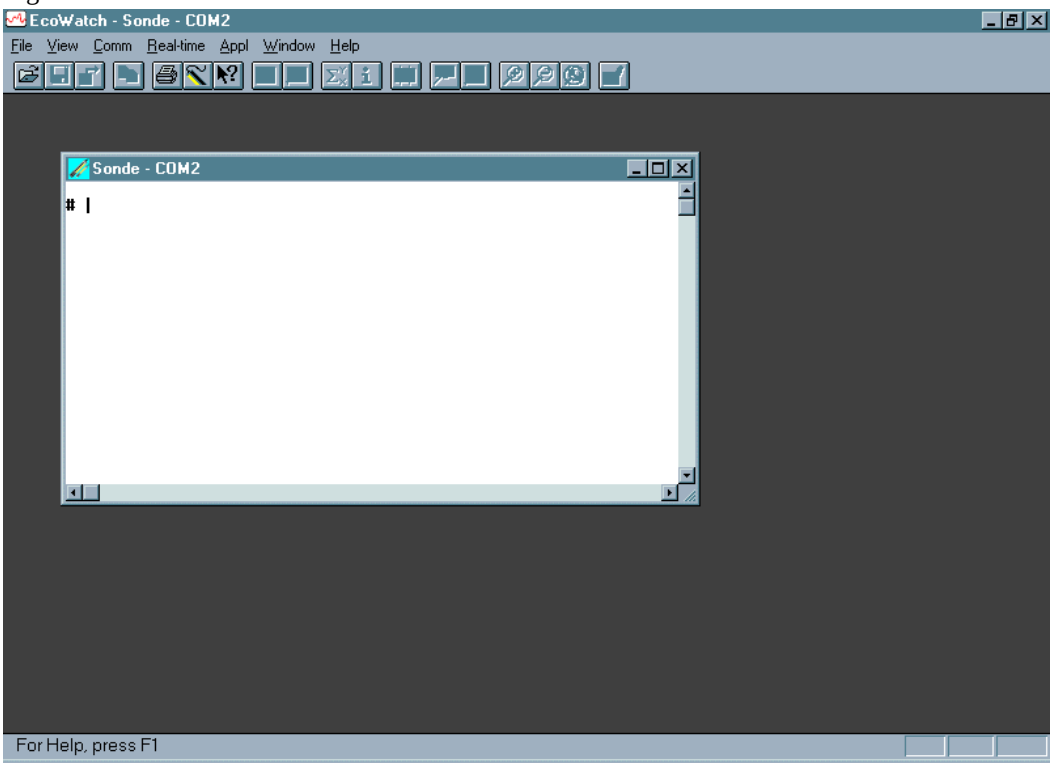
Your sonde menus will now appear in the language which you selected prior to running the updater. If you want to change the language associated with your sonde menu, you MUST rerun the YSI Code Updater and select the new language via this mechanism.

INTERFACING TO THE SONDE WITH ECOWATCH FOR WINDOWS

When you select **Sonde** from the EcoWatch for Windows menus, the PC-based software begins direct communication with the sonde-based software via standard VT100 terminal emulation.

In EcoWatch for Windows, select the sonde icon, . Then select the proper Com port and confirm by clicking **OK**. A window similar to that shown below will appear indicating connection to the sonde as shown in Figure 39. Type “**Menu**” after the **#** sign, press **Enter**, and the sonde Main menu will be displayed.

Figure 39



If your sonde has previously been used, the **Main menu** (rather than the # sign) may appear when communication is established. In this case simply proceed as described below. You will not be required to type "**Menu**".

If you are unable to establish interaction with the sonde, make sure that the cable is properly connected. If you are using external power, make certain that the YSI 6651 or 6038 power supply or other 12 vdc source is properly working. Recheck the setup of the Com port and other software parameters. Also refer to **Section 6, Troubleshooting**.

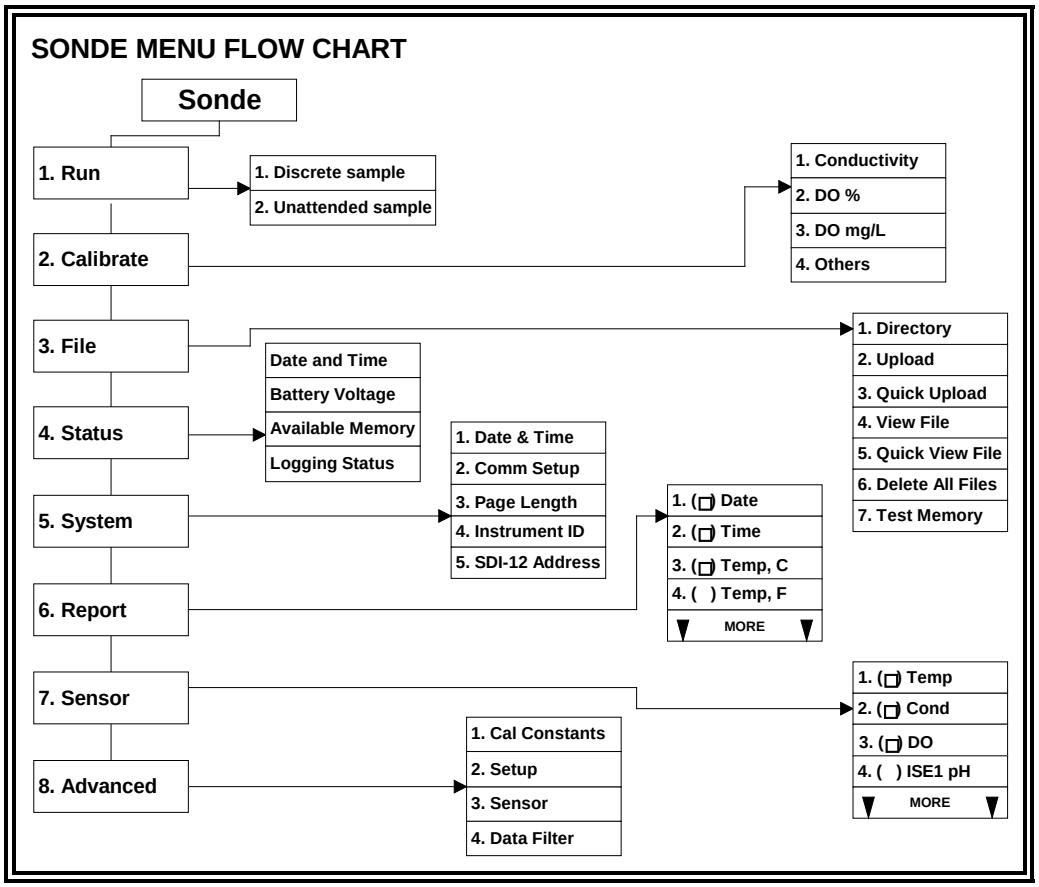
The sonde software is menu-driven. You select functions by typing their corresponding numbers. You do not need to press **Enter** after choosing a selection. Type the **0 or Esc** key to return to the previous menu.

Sonde Main Menu

```
------------------Main-----------------
1-Run                5-System
2-Calibrate          6-Report
3-File               7-Sensor
4-Status             8-Advanced

Select option (0 for previous menu):
```

Figure 40 - Sonde Menu Flow Chart



SYSTEM SETUP

At the Main menu, select **System**. The System Setup menu will be displayed.

System Setup Menu

```
1-Date & time
2-Comm setup
3-Page length=25
4-Instrument ID=YSI Sonde
5-Circuit board SN:00003001
6-GLP filename=00003001
7-SDI-12 address=0

Select option (0 for previous menu):
```

Select **1**-**Date & time**. An asterisk will appear next to each selection to confirm the entry. Press 4 and 5 to activate the date and time functions. Pay particular attention to the date format that you have chosen when entering date. You must use the 24-hour clock format for entering time. Option **4- ( ) 4 digit year** may be used so that the date will appear with either a two or four digit year display. If you do not enter the correct year format (8/30/**98** for 2-digit, 8/30/**1998** for 4 digit) your entry will be rejected.

```
----------Date & time setup----------
1-(*)m/d/y          4-( )4 digit year
2-( )d/m/y          5-Date=08/30/98
3-( )y/m/d          6-Time=11:12:30

Select option (0 for previous menu):
```

Select **4-Instrument ID** from the System setup menu to record the instrument ID number (usually the instrument serial number), and press **Enter**. A prompt will appear which will allow you to type in the serial number of your sonde. This will make sure that any data that is collected is associated with a particular sonde. Note that the selection **5-Circuit Board SN** shows the serial number of the PCB that is resident in your sonde (not the entire system as for Instrument ID). Unlike the **Instrument ID**, the user cannot change the **Circuit Board SN**. The **6-GLP filename** and **7-SDI-12 address** selections will be explained in Section 2.9.5

Press **Esc** or **0** to return to the **System setup** menu.

Then press **Esc** or **0** again to return to the **Main menu**.

```
-----------------Main----------------
1-Run               5-System
2-Calibrate         6-Report
3-File              7-Sensor
4-Status            8-Advanced

Select option (0 for previous menu):
```

ENABLING SENSORS

To activate the sensors that are in your sonde, select **Sensor** from the Sonde Main menu.

```
------------Sensors enabled------------
1-(*)Time
2-(*)Temperature
3-(*)Conductivity
4-(*)Dissolved Oxy
5-(*)ISE1 pH
6-(*)ISE2 Orp
7-(*)ISE3 NH4+
8-(*)ISE4 NO3-
9-( )ISE5 NONE
A-(*)Optic T Turbidity - 6136
B-(*)Optic C Chlorophyll

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors that are available on your sonde. Enter the corresponding number to enable the sensors that are installed on your sonde. An asterisk indicates that the sensor is enabled.

When selecting any of the ISE or Optical ports, a submenu will appear. When this occurs, make a selection so that the sensor corresponds to the port in which the sensor is physically installed. Only ORP can be enabled as ISE2. Optic T, Optic C, Optic B, and Optic O generate a submenu on selection. Each optical port can have one of six probes (6136 Turbidity, 6025 Chlorophyll, 6130 Rhodamine WT, 6131 BGA-PC, 6132 BGA-PE, or 6150 ROX Optical DO) installed as indicated by the submenus.

NOTE CAREFULLY: It is NOT possible to simultaneously activate BOTH the 6562 Rapid Pulse polarographic dissolved oxygen sensor and the 6150 ROX Optical dissolved oxygen sensor. Activation of either sensor will automatically deactivate the other selection. Thus, users of 6600V2-2, 6600EDS V2-2, 6820V2-1, and 6920V2-1 sondes CANNOT measure oxygen with both types of sensors.

After all installed sensors have been enabled, press **Esc or 0** to return to the Main Menu.

ENABLING PARAMETERS

In order for a specific parameter to be displayed:

1. The sensor must first be enabled as described above.
2. That parameter must be activated in the Report Setup menu described below.

Select **Report** from the Main menu. A Report Setup menu similar to the one shown below will be displayed.

```
--------------Report setup-------------
1-(*)Date m/d/y     E-(*)Orp mV
2-(*)Time hh:mm:ss  F-(*)NH4+ N mg/L
3-(*)Temp C         G-( )NH4+ N mV
4-(*)SpCond mS/cm   H-( )NH3 N mg/L
5-( )Cond           I-(*)NO3- N mg/L
6-( )Resist         J-( )NO3- N mV
7-( )TDS            K-(*)Cl- mg/L
8-( )Sal ppt        L-( )Cl- mV
9-(*)DOsat %        M-(*)Turbid+ NTU
A-(*)DO mg/L        N-(*)Chl ug/L
B-( )DOchrg         O-(*)Chl RFU
C-(*)pH             P-(*)Battery volts
D-( )pH mV

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors that are available and enabled on your sonde. The asterisks (*) that follow the numbers or letters indicate that the parameter will appear on all outputs and reports. To turn a parameter on or off, type the number or letter that corresponds to the parameter.

Note also that since a 6136 turbidity probe was selected in the Sensor menu above, the units of turbidity are presented as “turbid+ NTU”. If a 6026 turbidity probe (which was offered by YSI up until 2002) had been selected, the units of turbidity would be presented as “turbid NTU”. This designation is designed to differentiate the data from the two sensor types in later analysis.

For parameters with multiple unit options such as temperature, conductivity, specific conductance, resistivity and TDS, a submenu will appear as shown below for temperature, allowing selection of desired units for this parameter.

```
--------------Select units-------------
1-(*)NONE
2-( )Temp C
3-( )Temp F
4-( )Temp K

Select option (0 for previous menu): 2
```

After configuring your display with the desired parameters, press **Esc or 0** to return to the Main menu.

CHECKING ADVANCED SETTINGS

Select **Advanced** from the Main menu. The following menu will be displayed.

```
----------------Advanced-------------
1-Cal constants
2-Setup
3-Sensor
4-Data filter

Select option (0 for previous menu):
```

Select **Setup** from the Advanced menu.

```
-------------Advanced setup-----------
1-(*)VT100 emulation
2-( )Power up to Menu
3-( )Power up to Run
4-( )Comma radix
5-(*)Auto sleep RS232
6-(*)Auto sleep SDI12
7-( )Multi SDI12
8-( )Full SDI12

Select option (0 for previous menu): 0
```

Make sure that, other than **Auto sleep RS232**, all entries are activated or deactivated as shown above.

For sondes which will be used in sampling studies where the user is present and observes readings in real-time, **Auto sleep RS232** should usually be "off'. For sondes that will be used in unattended monitoring studies, **Auto sleep RS232** should usually be "on". This is described in detail in **Section 2.9, Sonde Menu**. When this setup is verified, press **Esc** or **0** to return to the Advanced menu.

Select **3-Sensor** from the Advanced menu and make certain that the entries are identical to those shown below.

```
------------Advanced sensor-----------
1-TDS constant=0.65
2-Latitude=40
3-Altitude Ft=0
4-(*)Fixed probe
5-( )Moving probe
6-DO temp co %/C=1.1
7-DO warm up sec=40
8-( )Wait for DO
9-Wipes=1
A-Wipe int=5
B-SDI12-M/wipe=1
C-Turb temp co %/C=0.3
D-(*)Turb spike filter
E-Chl temp co %/C=0
F-( )Chl spike filter

Select option (0 for previous menu):
```

If you have a depth sensor installed, you can maintain the default settings of 40 and 0 for **2-Latitude and 3-Altitude**, respectively, without affecting your ability to learn the basic calibration and operation of the sonde. However, if you know the appropriate values for your location, change them. When this setup is verified, press **Esc** or **0** to return to the Advanced menu. For more information, see **Section 2.9.8, Advanced**.

The display under **3-Sensor** may be different from the one shown in the example above, depending on the sensors that are installed in your unit. For example, if you do not have a chlorophyll probe, the last two entries (which are relevant only to chlorophyll) will not appear.

When this setup is verified, press **Esc** or **0** to return to the Advanced menu. For a detailed explanation of the choices in the Advanced menu, see **Section 2.9.8, Advanced**. Press **Esc** or **0** to back up to the Main menu.

```
------------------Main-----------------
1-Run               5-System
2-Calibrate         6-Report
3-File              7-Sensor
4-Status            8-Advanced

Select option (0 for previous menu):
```

The sonde software is now set up and ready to calibrate and run.

2.6 GETTING READY TO CALIBRATE

2.6.1 INTRODUCTION

HEALTH AND SAFETY

Reagents that are used to calibrate and check this instrument may be hazardous to your health. Take a moment to review health and safety information in **Appendix A** of this manual. Some calibration standard solutions may require special handling.

CONTAINERS NEEDED TO CALIBRATE A SONDE

The calibration cup that comes with your sonde serves as a calibration chamber for all calibrations and minimizes the volume of calibration reagents required.

Although not recommended except in unusual circumstances, instead of the calibration cup, you may use laboratory glassware to perform some of the calibrations. If you do not use a calibration cup that is designed for the sonde, you are cautioned to do the following:

- ✓ Perform all calibrations with the Probe Guard installed. This protects the probes from possible physical damage.
- ✓ Use a ring stand and clamp to secure the sonde body to prevent the sonde from falling over. Much laboratory glassware has convex bottoms.
- ✓ Insure that all sensors are immersed in calibration solutions. Many of the calibrations factor in readings from other probes (e.g., temperature probe). The top vent hole of the conductivity sensor must also be immersed during calibrations.

CALIBRATION TIPS

1. If you use the Calibration Cup for calibration of either the Rapid Pulse Polarographic or ROX Optical DO sensors in water-saturated air, make certain to loosen the seal to allow pressure equilibration before calibration.

2. If you choose to calibrate your Rapid Pulse Polarographic or ROX Optical DO sensor in air-saturated water in a separate vessel, be sure to sparge the water with an aquarium pump and air-stone for at least 1 hour to assure that the water is truly saturated with air.

3. The key to successful calibration is to insure that the sensors are completely submersed when calibration values are entered. Use recommended volumes when performing calibrations.

4. For maximum accuracy, use a small amount of previously used calibration solution to pre-rinse the sonde. You may wish to save old calibration standards for this purpose.

5. Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions or perform the calibration near a sink where the probes can be rinsed from the tap.

6. Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. Shake the excess rinse water off of the sonde, especially when the probe guard is installed. Dry off the outside of the sonde and probe guard. Making sure that the sonde is dry reduces carry-over contamination of calibrator solutions and increases the accuracy of the calibration.

7. Make certain that port plugs are installed in all ports where probes are not installed. It is extremely important to keep these electrical connectors dry.

USING THE CALIBRATION CUP

Follow these instructions to use the calibration cup for calibration procedures with all of the instruments except the 600R, 600QS, and 600 OMS V2-1. For these sondes, the over-the-guard bottle that comes with your sonde, must be used.

- ✓ Ensure that a gasket is installed in the gasket groove of the calibration cup bottom cap, and that the bottom cap is securely tightened. **Note:** Do not over-tighten as this could cause damage to the threaded portions of the bottom cap and tube.
- ✓ Remove the probe guard, if it is installed.
- ✓ Inspect the installed gasket on the sonde for obvious defects and if necessary, replace it with the extra gasket supplied.
- ✓ Screw the cup assembly into place on the threaded end of sonde and securely tighten. N**ote:** Do not over tighten as this could cause damage to the threaded portions of the bottom cap and tube.
- ✓ Sonde calibration can be accomplished with the sonde upright– i.e. the cable connector end of the sonde is oriented above the probe end, or inverted where the orientation is reversed. A separate clamp and stand, such as a ring stand, is required to support the sonde in the inverted position.
- ✓ When using the Calibration Cup for dissolved oxygen calibration in water-saturated air, make certain that the vessel is vented to the atmosphere by loosening the bottom cap or cup assembly, depending on orientation, and that approximately 1/8” of water is present in the cup.

NOTE CAREFULLY: If you are calibrating a 6136 turbidity sensor for use with a 6820V2-1 or 6920V2-1, you can use either the calibration cup supplied with your sonde or an optional extended length cup for the calibration. Please see the section below which describes the special calibration recommendations for this sensor.

RECOMMENDED VOLUMES OF CALIBRATION REAGENTS

The approximate volumes of the reagents are specified below for both the upright and inverted orientations. Note that the volume values are only estimates. The actual amount of calibrator solution required will depend on how many and what type of other probes are installed in you sonde bulkhead.

Table 1A 6820V2-1 and 6920V2-1 Sondes with Standard Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	200ml	150ml
pH/ORP	125ml	175ml
ISE	125ml	175ml
All Optical Sensors	50ml	DO NOT CALIBRATE***

Table 1B 6820V2-1 and 6920V2-1 Sondes with Optional Extended Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	320ml	150ml
pH/ORP	240ml	175ml
ISE	240ml	175ml
All Optical Sensors	225ml	DO NOT CALIBRATE***

Table 2 6820V2-2 and 6920V2-2 Sondes with Extended Calibration Cup*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	310ml	150ml
pH/ORP	200ml	150ml
ISE	200ml	150ml
All Optical Sensors	225 ml	DO NOT CALIBRATE***

Table 3 600XL and 600XLM Sondes

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	50ml	50ml
pH/ORP	25ml	50ml

Table 4 6600V2-2 Sonde with Short Calibration Cup and Long Cup in Parentheses*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	425ml (650ml)	250ml (250ml)
pH/ORP	300ml (500ml)	250ml (250ml))
ISE	300ml (500ml)	250ml (250ml)
All Optical Sensors	180ml (500ml)	DO NOT CALIBRATE***

Table 5 6600EDSV2-2 Sonde with Short Calibration Cup and Long Cup in Parentheses*

Probe to Calibrate	**Upright**	**Inverted**
Conductivity	275ml (520ml)	350ml (350ml)
pH/ORP	175ml (400ml)	350ml (350ml)
All Optical Sensors	225ml (420ml)	DO NOT CALIBRATE***

Table 6 6600V2-4 Sonde with Standard Long Calibration Cup****

Probe to Calibrate	Upright	Inverted
Conductivity	525ml	150ml
pH/ORP	500ml	150ml
All Optical Sensors	425ml	DO NOT CALIBRATE***

Table 7 600 OMS V2-1 Sonde* *

Probe to Calibrate	Upright	Inverted
Conductivity	375ml	N/A
Turbidity, Chlorophyll, Rhodamine WT	350ml	N/A

Table 8 600R and 600QS Sondes

Probe to Calibrate	Upright	Inverted
Conductivity	350ml	N/A
pH/ORP	120ml	N/A

* See section below for special instructions dealing with calibration of 6136 turbidity sensor.

** See section below for special instructions dealing with calibration of the conductivity sensor for the 600 OMS V2-1.

*** Optical Sensors CANNOT be calibrated with the sonde in the Upside-Down position because of interference from the meniscus of the calibration standard.

**** An extended length calibration cup is supplied with the 6600V2-4, 6600V2-2, and 6600EDSV2-2 to facilitate calibration of the 6136 turbidity sensor. This cup requires the use of larger volumes of other calibration solutions. Users may choose to purchase the shorter calibration cup sleeve for calibration of sensors other than the 6136 to reduce the volumes of calibrant. The shorter cal cup sleeve is YSI Item Number 066267 and can be obtained by contacting YSI Technical Support.

CALIBRATION OF THE 6136 TURBIDITY SENSOR

The 6136 can be calibrated using either the calibration cup supplied with the sonde or with an extended length calibration cup which can be purchased as an option for the 6820V2-1 and 6920V2-1. An extended cup is supplied as a standard item with the 6820V2-2, 6920V2-2, 6600V2-4, 6600V2-2, and 6600EDSV2-2 sondes. If you choose to calibrate with the short calibration cup, you also MUST first make certain that the vessel is equipped with a BLACK bottom. In addition, you should engage only ONE THREAD when screwing the calibration cup onto the sonde in order to keep the turbidity probe face as far as possible from the calibration cup bottom to avoid interference. Even with these techniques, there will still be a small interference from the bottom of the calibration cup that will cause your field turbidity readings to be approximately 0.5 NTU lower than the actual reading. This small error is usually only evident when the sonde is deployed in very clear water where the readings might appear as slightly negative values, e.g., a turbidity of 0.1 NTU would appear as –0.4 NTU.

Use of the extended length cup will require the use of significantly more standard solutions for 6820V2-1/ 6920V2-1 sondes (additional 180 mL) if calibration is done in the upright position. To minimize calibration solution volumes for sensors other than turbidity, users may wish to purchase the shorter calibration cup sleeve which is supplied as standard with the 6820V2-1 and 6920V2-1. The shorter cal cup sleeve for any 6600 is Item Number 066267, and the shorter cal cup sleeve for any 6820/6920 is Item Number 069286. These can be ordered from YSI Technical Support.

NOTE CAREFULLY: All optical sensors MUST be calibrated in the upright position no matter which type of calibration cup is employed. In the upside-down position, the meniscus of the standard causes a great deal of interference and this interference is likely to result in calibration errors and/or erroneous field readings.

CALIBRATION OF 600 OMS V2-1 CONDUCTIVITY SENSOR

In order to conserve calibration solution, the 600 OMS V2-1conductivity sensor should be calibrated with the optical probe removed and the optical port plug securely tightened. The volume of conductivity solution provided in Table 7 above reflects this special condition. In addition, it is recommended that the sonde be shaken vigorously after immersion in the conductivity reagent to assure that bubbles are expelled from the cell.

An instruction sheet dealing in greater detail with the special requirements for calibration of 600 OMS V2-1sensors is included with the sonde. Be sure to read the instructions carefully before using the sonde.

2.6.2 CALIBRATION PROCEDURES

The following calibration procedures are the most commonly used methods for the 6-series sensors. For detailed information on all calibration procedures, refer to **Section 2.9.2, Calibrate**.

To ensure more accurate results, you can rinse the calibration cup with water, and then rinse with a small amount of the calibration solution for the sensor that you are going to calibrate. Discard the rinse solution and add fresh calibrator solution. Use tables 1-8 to find the correct amount of calibrator solution.

1. Carefully immerse the probes into the solution and rotate the calibration cup to engage several threads. YSI recommends supporting the sonde with a ring stand and clamp to prevent the sonde from falling over.

2. With the proper cable, connect the sonde to a PC, access EcoWatch for Windows and proceed to the Main menu (for information on how to run EcoWatch for Windows software, see **Section 2.4.2, Running EcoWatch Software)**. From the sonde Main menu, select **2-Calibrate**.

```
---------------Calibrate-------------
1-Conductivity      6-ISE3 NH4+
2-Dissolved Oxy     7-ISE4 NO3-
3-Pressure-Abs      8-Optic T-Turbidity-6026
4-ISE1 pH           9-Optic C-Chlorophyll
5-ISE2 ORP

Select option (0 for previous menu):
```

3. Note that the exact appearance of this menu will vary depending upon the sensors that are available and enabled on your sonde. To select any of the parameters from the Calibrate menu, input the number that is next to the parameter. Once you have chosen a parameter, some of the parameters will have a number that appears in parentheses. These are the default values and will be used during calibration if you press **Enter** without inputting another value. Be sure not to accept default values unless you have assured that they are correct. If no default value appears, you must type a numerical value and press **Enter**.

4. After you input the calibration value, or accept the default, press **Enter**. A real-time display will appear on the screen. Carefully observe the stabilization of the readings of the parameter that is being calibrated. When the readings have been stable for approximately 30 seconds, press **Enter** to accept the calibration. The calibrated value is bolded on the example screen on the following page.

5. Press **Enter** to return to the Calibrate menu, and proceed to the next calibration.

CALIBRATION EXAMPLE

The example below for calibration of specific conductance, is designed to demonstrate the general calibration protocol for all parameters. From the Calibrate menu, press **1-Conductivity** and the following display will be shown.

```
------------Cond calibration-----------
1-SpCond
2-Cond
3-Salinity

Select option (0 for previous menu): 1
```

Select **1-SpCond** (the generally-recommended method for calibration of a conductivity sensor) and the following prompt will appear which calls for your numerical input of the specific conductance of your calibration solution.

```
Enter SpCond in mS/cm (10):
```

As noted above, the number in parentheses is the default value of this parameter and will be used in the calibration if *only* **Enter** is pressed without typing in another value. Similar prompts will be displayed during the calibration of all parameters, but for some sensors, such as pH, no default values are provided. In these cases, the user must input a numerical value and then press **Enter**.

After the correct calibration value for your solution is input and **Enter** is pressed, a real-time display similar to the following will then appear on the screen..

```
Date     Time     Temp SpCond   Cond   Sal DOsat     DO    Depth   pH   Battery
mm/dd/yy hh:mm:ss   C  mS/cm    mS/cm  ppt     %    mg/L    feet         volts
-------------------------------------------------------------------------------
To calibrate, press <Enter> when the readings are stable.

05/05/97 08:39:51 20.83 9.602 8.837   5.41  37.9   3.28  -0.252  7.06    10.2
```

Note that all parameters that have been enabled will appear - not just the one being calibrated at the moment. The user should carefully observe the stabilization of the readings of the parameter that is being calibrated and, when the readings are stable for approximately 30 seconds, press **Enter** to implement the calibration and the following message will appear.

```
Calibrated.  Press <Enter> to continue.
```

NOTE: If an ERROR message appears, begin the calibration procedure again. Be certain that the value you enter for the calibration standard is correct. Also see **Section 6, Troubleshooting** for more information on error messages.

CAUTION: Be certain to **immerse the entire sonde** in solution standards for calibration of all parameters. Most calibrations require readings not only from the sensor being calibrated but also from the temperature sensor.

Specific start-up calibration procedures for all sensors that commonly require calibration are provided in the following paragraphs of this section. Remember that these are basic protocols designed to get the user up and running with your 6-series sonde. A more-detailed discussion of sensor calibration can be found in Section 2.9.2.

CONDUCTIVITY

This procedure calibrates conductivity, specific conductance, salinity, and total dissolved solids.

Place the correct amount (see Tables 1-8) of 10 mS/cm conductivity standard (YSI 3163 is recommended) into a clean, dry or pre-rinsed calibration cup.

Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the conductivity sensor with a small amount of standard that can be discarded. Be certain that you avoid cross-contamination of standard solutions with other solutions. Make certain that there are no salt deposits around the oxygen and pH/ORP probes, particularly if you are employing standards of low conductivity.

Carefully immerse the probe end of the sonde into the solution. Gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell. The probe must be completely immersed past its vent hole. Using the recommended volumes from the table in the previous subsection should insure that the vent hole is covered.

Allow at least one minute for temperature equilibration before proceeding.

From the Calibrate menu, select **Conductivity** to access the Conductivity calibration procedure and then **1-SpCond** to access the specific conductance calibration procedure. Enter the calibration value of the standard you are using (mS/cm at 25°C) and press **Enter**. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.

Observe the readings under Specific Conductance or Conductivity and when they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in tap or purified water and dry the sonde.

NOTE: The YSI conductivity system is very linear over its entire 0-100 mS/cm range. Therefore, it is usually not necessary to use calibration solutions other than the 10 mS/cm reagent recommended above for all environmental applications from low conductivity freshwater to seawater. YSI does offer the 3161 (1 mS/cm) and 3165 (100 mS/cm) conductivity standards for users who want to assure maximum accuracy at the high and low ends of the sensor range. Users of the 1 mS/cm standard should be particularly careful to avoid contamination of the reagent. In fact, because of contamination issues, YSI does not recommend using standards less than 1 mS/cm.

NOTE: For calibration of the 600 OMS V2-1conductivity sensor, the optical probe must be removed and the port plugged. See specific instructions in the application note supplied with the 600 OMS V2-1.

RAPID PULSE POLAROGRAPHIC DISSOLVED OXYGEN

Place approximately 3 mm (1/8 inch) of water in the bottom of the calibration cup. Place the probe end of the sonde into the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.

Two calibration protocols are provided below for Rapid Pulse dissolved oxygen, one for sampling applications and one for long-term monitoring applications.

Sampling Applications

If your instrument will be used in sampling applications where the dissolved oxygen is "on" continuously during the study, deactivate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**.

From the Calibrate menu, select **Dissolved Oxy**, then **1-DO %** to access the DO percent calibration procedure. Calibration of dissolved oxygen in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in mm of Hg. (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in feet above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under DO%. When they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the Calibrate menu.

Rinse the sonde in water and dry the sonde.

Monitoring Applications

If your instrument will be used in monitoring applications where data is being captured at a longer interval (e.g. 15 – 60 minutes) to internal sonde memory, a data collection platform or a computer, you need to activate "Autosleep RS232" as described in **Section 2.5, Sonde Software Setup**. Then follow the instructions detailed above for the Sampling Application calibration. With Autosleep active, the calibration will occur automatically with a display similar to that shown below.

```
=================================================================
 Temp SpCond    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
    C  mS/cm    ppt     %   mg/L    feet         mg/L   mg/L    NTU
-----------------------------------------------------------------
Stabilizing: 38
```

After the warm-up time is complete, the readings just before and just after calibration are displayed. When you press **Enter**, the screen returns to the DO Calibration menu.

ROX OPTICAL DISSOLVED OXYGEN

Place the sensor either (a) into a calibration cup containing about 1/8 inch of water which is vented by loosening the threads or (b) into a container of water which is being continuously sparged with an aquarium pump and air stone. Wait approximately 10 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

Select **ODOsat %** and then **1-Point** to access the DO calibration procedure. Calibration of your Optical dissolved oxygen sensor in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in **mm of Hg.** (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODOsat %. When they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the **Calibrate** menu.

The minor advantages and disadvantages of calibration in air-saturated water versus water-saturated air are outlined in **Appendix M, ROX Optical DO Sensor**

NOTE CAREFULLY: As opposed to the 6562 Rapid Pulse Polarographic DO sensor described above, there is no difference between the calibration routine for sensors which will be used for sampling or monitoring applications. Usually the Autosleep RS-232 feature in the **Advanced|Setup** menu will be activated for ROX calibrations, but there is no problem if it is not active.

Rinse the sonde in water and dry the sonde.

DEPTH AND LEVEL

For the depth and level calibration, make certain that the depth sensor module is in air and not immersed in any solution.

From the Calibrate menu, select **Pressure-Abs** (or **Pressure-Gage** if you have a vented level sensor) to access the depth calibration procedure. Input 0.00 or some known sensor offset in feet. Press **Enter** and monitor the stabilization of the depth readings with time. When no significant change occurs for approximately 30 seconds, press **Enter** to confirm the calibration. This zeros the sensor with regard to current barometric pressure. Then press **Enter** again to return to the Calibrate menu.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH 2-POINT

Using the correct amount of pH 7 buffer standard (see Tables 1-8) in a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

From the Calibrate menu, select **ISE1 pH** to access the pH calibration choices and then press **2- 2-Point**. Press **Enter** and input the value of the buffer at the prompt.

NOTE: The actual pH value of all buffers is somewhat variable with temperature and that the correct value from the bottle label for your calibration temperature should be entered for maximum accuracy. For example, the pH of YSI "pH 7 Buffer" is 7.00 at 25 C, but 7.02 at 20 C.

After entering the correct pH value of the buffer, press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. The display will indicate that the calibration is accepted.

After the pH 7 calibration is complete, press **Enter** again, as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde before proceeding to the next step.

Using the correct amount (see Tables 1-8) of an additional pH buffer standard into a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the correct value of the second buffer for your calibration temperature at the prompt. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under pH and when they show no significant change for approximately 30 seconds, press **Enter**. After the second calibration point is complete, press **Enter** again, as instructed on the screen, to return to the Calibrate menu.

Rinse the sonde in water and dry. Thoroughly rinse and dry the calibration containers for future use.

NOTE: The majority of environmental water of all types has a pH between 7 and 10. Therefore, unless you anticipate a pH of less than 7 for your application, YSI recommends a two point calibration using pH 7 and pH 10 buffers.

The next calibration instructions are only for the ISE sensors which are options for the 6820V2-1, 6800V2-2, 6600V2-2, 6920V2-1, and 6920V2-2 sondes. If you do not have one of these sondes, you may skip to the next section.

AMMONIUM (NH_4^+) , CHLORIDE CL^- AND NITRATE (NO_3^-) 3-POINT

WARNING: AMMONIUM AND NITRATE SENSORS CAN ONLY BE USED AT DEPTHS OF LESS THAN 50 FEET (15 METERS). USE OF THE SENSORS AT GREATER DEPTHS IS LIKELY TO PERMANENTLY DAMAGE THE SENSOR MEMBRANE.

The calibration procedures for ammonium, nitrate or chloride are similar to pH except for the reagents in the calibration solutions. Suggested values for calibrants are 1 and 100 mg/L of either ammonium-nitrogen (NH_4-N) or nitrate-nitrogen (NO_3-N). Suggested values for calibrants are 10 and 1000 mg/L of Chloride (Cl^-).

NOTE: The following procedure requires one portion of the high concentration calibrant and two portions of the low concentration calibrant. The high concentration solution and one of the low concentration solutions should be at ambient temperature. The other low concentration solution should be chilled to less than 10°C prior to beginning the procedure.

Place the proper amount of 100 mg/L standard (1000mg/l for chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Select **Ammonium, Nitrate,** or **Chloride** to access the appropriate calibration choices. Then select **3-3-Point**. Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$, or Cl^- . When they show no significant change for approximately 30 seconds, press **Enter**.

After the first calibration point is complete, proceed as instructed on the screen, to continue. Rinse the sonde in water and dry the sonde prior to the next step.

Place the proper amount of 1 mg/L standard for Ammonium or Nitrate (10 mg/l for Chloride) into a clean, dry or pre-rinsed transport cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested.

Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$, or Cl^-.and when they have show no significant change for approximately 30 seconds, press **Enter**.

After the second value calibration is complete, press **Enter** to continue. Place the proper amount of chilled 1 mg/L standard (10 mg/L for the chloride) into a clean, dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution. Allow at least 5 minutes for temperature equilibration before proceeding.

Press **Enter** and input the concentration value of the standard as requested. Press **Enter** and the current values of all enabled sensors will appear on the screen and will change with time as they stabilize in the solution. Observe the readings under $NH4^+$, $NO3^-$ or Cl^- and when they show no significant change for approximately 30 seconds, press **Enter**. After the third value calibration is complete, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

CALIBRATION TIP: Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in these ISE probes (ammonium, nitrate and chloride probes). Therefore, when calibrating the pH probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

- Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with the calibration.

- When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

TURBIDITY 2-POINT

Select **Optic X –Turbidity-6136** or **Optic X – Turbidity 6026** from the Calibrate Menu and then **2-2-Point**.

NOTE: Before calibrating your 6136 turbidity sensor, pay particular attention to the following cautions:

- To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6026 and 6136 by either YSI or approved vendors who are listed on the YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS ARE **NOT** APPROVED FOR THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

- For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which YSI turbidity sensor (Legacy 6026 or Current 6136) is being calibrated. This reflects the empirically determined fact that 6026 and 6136 sensors that have been calibrated to the same value in the primary standard formazin, will have different responses in suspensions of the AEPA-AMCO beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

- When calibrating a 6136 turbidity sensor you MUST carefully follow the instructions found above in Section 2.6.1 to avoid interference from the bottom of the calibration cup. Failure to carry out the calibration properly can result in inaccurate readings, particularly water of very low turbidity.

- Before proceeding with the calibration, be certain that the probe compartment of the sonde has been cleaned and is free of debris. Solid particles from this source, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data.

- One standard must be 0 NTU, and this standard must be calibrated first.

To begin the calibration, place the correct amount (see Tables 1-8 above) of 0 NTU standard (clear deionized or distilled water) into the calibration cup provided with your sonde. Immerse the sonde in the water**.** Input the value 0 NTU at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen, to remove any bubbles. After stabilization is complete, press **Enter** to "confirm" the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second turbidity standard (100 or 126 NTU is suggested) using the same container as for the 0 NTU standard. Input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the "3" key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the turbidity sensor, see **Appendix E, Turbidity Measurements**.

CHLOROPHYLL 1-POINT

Select **Optic X -Chlorophyll** from the **Calibrate** Menu, **Chl µg/L** and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in µg/L, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to chlorophyll. However, the readings will reflect changes in chlorophyll from site to site, or over time at a single site.

To increase the accuracy of your chlorophyll measurements, follow the 2-point or 3-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.14**, **Chlorophyll a**nd **Appendix I, Chlorophyll Measurements** that describe practical aspects of fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 µg/L at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the chlorophyll sensor, see **Section 5.14**, **Chlorophyll** and **Appendix I, Chlorophyll Measurements.**

BGA-PC 1-POINT

Select **Optic X BGA-PC -** from the **Calibrate** Menu, and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycocyanin-containing BGA in cells/mL, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PC. However, the readings will reflect changes in BGA-PC from site to site, or over time at a single site.

To increase the accuracy of your BGA-PC measurements, follow the 2-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.16, Principles of Operation** to better understand the practical aspects of BGA-PC fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 cells/mL at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu. Note that because the range of the BGA sensors in cells/mL is large, the readings may appear to be somewhat noisier during the calibration procedure than for other 6-series sensors. Variations of +/- 400 cells/mL for the zero point can be observed with a properly functioning sensor since this value is only 0.2% of the range.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the BGA-PC sensor, see **Section 5.16, Principles of Operation.**

Note that the 1-point calibration of the BGA-PC sensor in cells/mL will also zero the PC RFU (Relative Fluorescence Units) parameter which is in units of percent of the full scale of the sensor. Users may wish to activate PC RFU in the Report menu and simply use this parameter to determine BGA-PC events until a good correlation between the observed cells/mL value and the value determined from laboratory analysis has been established.

BGA-PE 1-POINT

Select **Optic X BGA-PE -** from the **Calibrate** Menu, and then **1-1 point.**

NOTE: This procedure will zero your fluorescence sensor and use the default sensitivity for calculation of phycoerythrin-containing BGA in cells/mL, allowing quick and easy fluorescence measurements that are only semi-quantitative with regard to BGA-PE. However, the readings will reflect changes in BGA-PE from site to site, or over time at a single site.

To increase the accuracy of your BGA-PE measurements, follow the 2-point calibration protocols outlined in **Section 2.9, Sonde Menu**.

Before making any field readings, carefully read **Section 5.17, Principles of Operation** to better understand the practical aspects of BGA-PE fluorescence measurements.

To begin the calibration, place the correct amount (see Tables 1-8 above) of clear deionized or distilled water into the YSI clear calibration cup provided. Immerse the sonde in the water**.** Input the value 0 cells/mL at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen to remove any bubbles from the sensor. After stabilization is complete, press **Enter** to "confirm" the calibration and then, as instructed, press **Enter** to return to the Calibrate menu. Note that because the range of the BGA sensors in cells/mL is large, the readings may appear to be somewhat noisier during the calibration procedure than for other 6-series sensors. Variations of +/- 400 cells/mL for the zero point can be observed with a properly functioning sensor since this value is only 0.2% of the range.

Thoroughly rinse and dry the calibration cups for future use. For additional information related to calibrating the BGA-PE sensor, see **Section 5.17, Principles of Operation.**

Note that the 1-point calibration of the BGA-PE sensor in cells/mL will also zero the PE RFU (Relative Fluorescence Units) parameter which is in units of percent of the full scale of the sensor. Users may wish to activate PC RFU in the Report menu and simply use this parameter to determine BGA-PE events until a

good correlation between the observed cells/mL value and the value determined from laboratory analysis has been established.

RHODAMINE WT 2-POINT

Select **Rhodamine** from the **Calibrate** Menu and then **2-2-Point**.

NOTE: One standard must be 0 ug/L in rhodamine WT, and this standard must be calibrated first.

To begin the calibration, place the correct amount (see Tables 1-8) of 0 standard (clear deionized or distilled water) into the calibration cup provided with your sonde and immerse the sonde in the water**.** Input the value 0 ug/L at the prompt, and press **Enter**. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Activate the wiper 1-2 times by pressing **3-Clean Optics** as shown on the screen, to remove any bubbles. After stabilization is complete, press **Enter** to "confirm" the first calibration and then, as instructed, press **Enter** to continue.

Dry the sonde carefully and then place the sonde in the second rhodamine WT standard (100 ug/L is recommended) using the same container as for the 0 ug/L standard. Input the correct rhodamine WT concentration in ug/L, press **Enter**, and view the stabilization of the values on the screen in real-time. As above, activate the wiper with the "3" key or manually rotate the sonde to remove bubbles. After the readings have stabilized, press **Enter** to confirm the calibration and then press **Enter** to return to the Calibrate menu.

Thoroughly rinse and dry the calibration cups for future use.

2.7 TAKING READINGS

After you have (1) enabled the sensors, (2) set the report to show the parameters that you want to see, and (3) calibrated the sensors, you are now ready to take readings.

There are two basic approaches to sampling, discrete and unattended. Using discrete sampling, the sonde is connected via a communication cable to a PC or 650 MDS Display/Logger. The sampling frequency is likely to be rapid (seconds) in order to obtain a representative sampling as you move from site to site. Readings will probably be logged to several different files.

Unattended sampling is normally done with sondes that have internal batteries. The sampling frequency is likely to be longer (minutes or hours). A sonde is typically deployed for days or weeks at a time, and readings will be logged to a single file. The communication cable may be disconnected and internal battery power used to operate the sonde. Alternatively, the sonde may connect via SDI-12 communication to a data collection platform (DCP). Sondes without batteries need to be connected to an external power source for unattended sampling.

Select **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run menu as shown below.

```
---------------Run setup--------------
1-Discrete sample   2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Select **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
------------Discrete sample------------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

Select **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. See Section 2.9.1 for more details.

Select **3-File** to enter a filename with a maximum of 8 characters. This is the file to which you will log readings.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press 1-LOG last sample or 2-LOG ON/OFF from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

Select **4-Site** to assign a site name with a maximum of 31 characters. This allows you to enter the name of the site where you are sampling.

When you select **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and number 5 changes back to **Open File**.

Now select **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, (e.g. 4 seconds in the example above), sequential lines of data will appear on the screen.

```
============================================================
 Temp    Sal DOsat     DO   Depth    pH NH4+ N NO3- N Turbid
   C     ppt     %   mg/L    feet         mg/L   mg/L    NTU
------------------------------------------------------------
*** 1-LOG last sample   2-LOG ON/OFF, 3-Clean optics ***
23.54   0.00  96.5   8.20   1.001  5.20  0.853  0.522    0.3
*** LOG is ON,  hit 2 to turn it OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.001  5.20  0.856  0.520    0.3
23.53   0.00  96.5   8.20   1.000  5.20  0.854  0.521    0.3
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
*** 1-LOG last sample   2-LOG ON/OFF, 3-Clean optics ***
23.53   0.00  96.5   8.20   1.000  5.19  0.852  0.522    0.3
Sample logged.
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics.

By entering **1–LOG last sample**, a single line of data can be logged to sonde memory and the following message will be displayed: **Sample logged.**

By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

By entering **3-Clean optics**, if your unit has an optical probe, the wiper will clean the optical surface**.** The **3-Clean optics** portion of the prompt will only appear if an optical probe was installed and enabled.

Select **Esc** or press **0** to exit discrete sampling.

UNATTENDED SAMPLING

Select **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

> **Example:** You are going to deploy the sonde for 2 weeks, collecting a set of readings every 15 minutes. You start at 6:00 PM on July 17, 1996 and end the

sampling at 6:00 PM on July 31, 1996. The site is Clear Lake, near the spillway, and you want to log all of the readings to a single file CLRLAKE3.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=
6-Site=
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your sonde for unattended deployment as described below:

To verify and/or correct the time and date enter **4-Status** or **5-System menu** from the Main menu. You may enter the correct date and time from either of these submenus.

- Select **1-Interval** and enter the desired time between samples (e.g. 15 minutes in the screen above). Use the 24-hour clock format to enter interval.

- Select **2-Start Date** and **3-Start Time** to set the time that data will begin to log to sonde memory. If you do not make any change to these entries, then the study will automatically begin at the next integral time interval, once you have pressed **C-Start logging**.

  Example: If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory. If you should desire to start the instrument at the site at 6:00 PM as noted in the above example, change the Start Time to 18:00:00.

- Select **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study. Be sure to use ONLY alpha/numeric characters.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software.

- Skip **B-View params to log** in this initial test study. This feature will be explained in detail in **Section 2.9, Sonde Menu**.

After making the above entries, the sonde software will automatically calculate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration as items 8, 9, and A. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the entries. For example, you can free up memory in the sonde by uploading all existing data from the sonde memory to your PC and then deleting them out of the sonde (see 3-File from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

Review the screen below, which now displays the entries made above and reflects your logging conditions.

```
------------Unattended setup-----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=365
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 11.6
8-Bat life 25.1 days
9-Free mem 41.3 days
A-1st sample in 4.10 minutes
B-View params to log
C-Start logging
```

Once you press **C-Start logging**, a screen will appear to request confirmation.

```
-------------Start logging-------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select **1-Yes** and the screen will change.

```
----------------Logging---------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 11.7
9-Bat life 25.5 days
A-Free mem 41.3 days
B-Stop logging
C-Show Live Data

Select option (0 for previous menu):
```

The display now shows the next date and time for logging, and the stop date and time for the logging study. Most importantly, note that the "B" command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

The Unattended study will terminate when the duration you specified has expired or the batteries are expended. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**. Select **1-yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.8 USING ECOWATCH TO CAPTURE, UPLOAD AND ANALYZE DATA

EcoWatch for Windows software is reporting and plotting software for use with the YSI 6-Series sondes. Instructions for installing this software were included in **Section 2.1, Getting Started**. This program can also be used to upload and view data logged to sonde memory during either discrete or unattended sampling.

CAPTURE

EcoWatch for Windows can be used to capture data in real-time to your PC's hard drive or to a floppy disk. To utilize this function, interface the sonde to your PC via a COM port, run EcoWatch for Windows, and follow the step by step instructions below.

1. Click on the sonde icon , choose the proper Com port, and confirm.

2. From the **Main** sonde menu press **1-Run** and then **1-Discrete Sample**.

3. Make sure that the sample interval is set to the correct value. If it is not, change it to the correct value.

4. Close the terminal window by clicking on the **X** in the upper right hand corner. Do not close EcoWatch for Windows.

5. Open the **Real-Time** menu, click on **New** and select the location where you want to data transferred. Name the file, making sure that the name has extension **.RT**. The default location for the file is in the Data subdirectory of the ECOWWIN directory.

6. Click **OK**. After EcoWatch sets up the sonde for the study, data transfer will begin at the sample rate you selected. The data will be automatically plotted with autoscaling and saved as a .DAT file at your chosen selection.

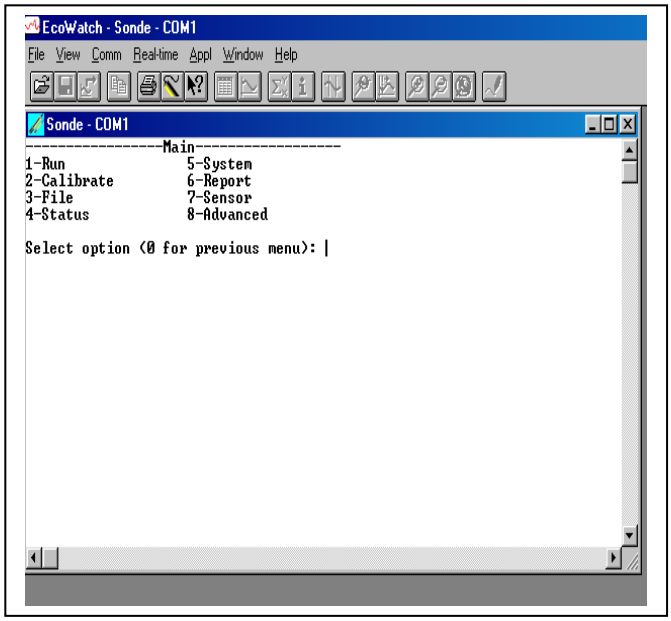
7. To terminate the study, open the **Real-Time** menu, choose **Close**, and click **OK**.

UPLOAD DATA

If the sonde was deployed unattended (without a cable), clear debris and water from the bulkhead connector cap. Then remove the cap and connect the calibration cable (or field cable and adapter) from the sonde to your computer.

You may now retrieve data files using the following procedure. Remember these are files in the sonde directory, not files in the EcoWatch directory.

Run EcoWatch software on your PC and select the **Sonde** icon from the menu bar. A terminal interface window (like that shown below) will appear. If a "#" prompt appears instead of the Main sonde menu, type "menu" at the prompt to generate the display as shown. Then press **3-File** to view data handling options.




```
----------File----------
-
1-Directory          4-View file
2-Upload             5-Quick view file
3-Quick Upload       6-Delete all files

Select option (0 for previous menu): 1
```

Select **1-Directory** to view all files currently stored in the sondes flash disk memory, the screen below shows 6 files. All data files (.dat extension) could be uploaded to EcoWatch for viewing or plotting, but you do not need to upload all files in the directory. The file with the .glp extension contains the calibration record of the sonde. It is fully described in Sections 2.9.2 and 2.9.3 below. Details of any of the studies can be obtained by pressing the number key associated with the file in the Directory.

```
 Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6-00003001.glp      3

Select option (0 for previous menu): 4
```

```
-------------File details--------
------
1-View file
2-File:CLRLAKE2.dat
3-Samples:    167
4-Bytes:   4421
5-First:08/23/2001
6-First:08:33:40
7-Last :08/23/2001
8-Last :09:04:20
9-Interval:00:00:10
A-Site:Clear Lake
```

Select **2-Upload** to view file lists in memory, and upload the data to PC-based software.

Prior to upload, a "**Time window**" display appears that will allow you to select portions of the logged data to upload. You may select **1-Proceed** to upload all logged data from the dates and times displayed.

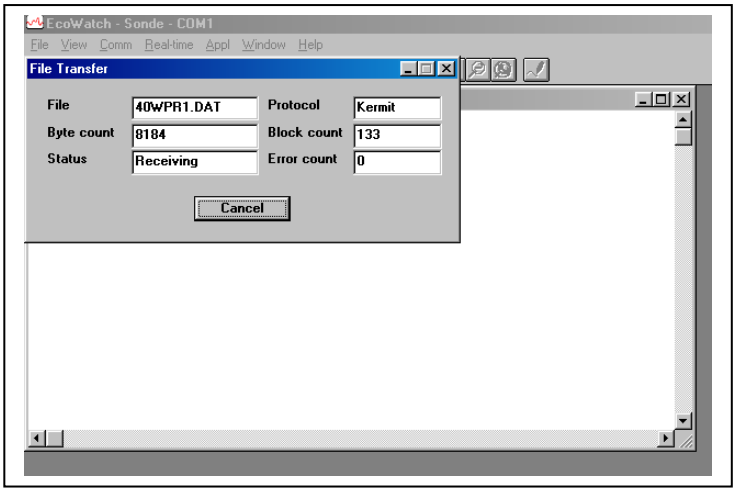
```
--------------Time window--------------
1-Proceed
2-Start date=08/14/96
3-Start time=18:00:00
4-Stop  date=08/28/96
5-Stop  time=11:00:00

Select option (0 for previous menu):
```

Select **1-Proceed**. Choose the appropriate file transfer protocol (in this example, PC6000) and a status box will show the progress of the upload. Verification of a successful transfer is indicated when all of the requested data have been transferred to the C:\ECOWIN\DATA subdirectory of your PC and automatically assigned a ".DAT" extension.

```
---------------File type---------------
1-PC6000
2-Comma & ' ' Delimited
3-ASCII Text

Select option (0 for previous menu):
```



Select **3-Quick Upload** to transfer the last logged file in its entirety to your computer. As noted above, the file will then be resident in the C:\ECOWIN\DATA subdirectory.

Select **4-View File** to examine the data in any file currently stored in the sondes flash disk memory. You will first view the same screen as viewed in the Directory menu. From this menu choose the file of interest, then, using the Time window menu, choose the dates and/or times of interest. If you choose dates or times that are not within the designated start and stop times, no data will be displayed.

You also may choose the entire file. You can use the **Space Bar** to stop and restart the scrolling at any time. Use the **Esc** key to stop the view.

Select **5-Quick view file** to view the last page of data from the last data file in flash disk memory. This feature is particularly useful to quickly review any recently acquired data so that system performance can be assessed.

Select **6-Delete** all files to ***IRREVERSIBLY*** remove all files (INCLUDING the .glp file that contains calibration information) from the sonde flash disk memory. It is critical not to use this option until all relevant data from sonde memory is transferred to your computer via one of the upload options. There is a verification screen that appears, so that pressing the number 6-key does not immediately delete all files.

NOTE: By choosing the Delete function **only** .dat and .glp files will be erased. Calibration data for all sensors installed and calibrated on the sonde will not be deleted.

REPORTING AND PLOTTING DATA WITH ECOWATCH

There are many features in EcoWatch related to viewing, plotting, manipulating and reporting data collected from a 6-Series sonde. EcoWatch includes a Windows Help section for convenient reference that describes all of the software's features. This section of the manual describes the most commonly used functions of the program and Section 4, **EcoWatch for Windows**, is a detailed manual for EcoWatch software.

For the purposes of describing and demonstrating EcoWatch plotting, reporting and data manipulation capabilities, we use the file SAMPLE.DAT available on the compact disk that was enclosed with your 6-series sonde. This file will be copied to your hard drive during EcoWatch installation and should be available to you for the instructions below.

When you are ready to move beyond the example SAMPLE.DAT file and analyze data collected from the sonde, locate and open the appropriate .DAT file from your data upload exercise. These data are normally found at C:\ECOWWIN\DATA\. An example filename is 1097CM01.DAT.

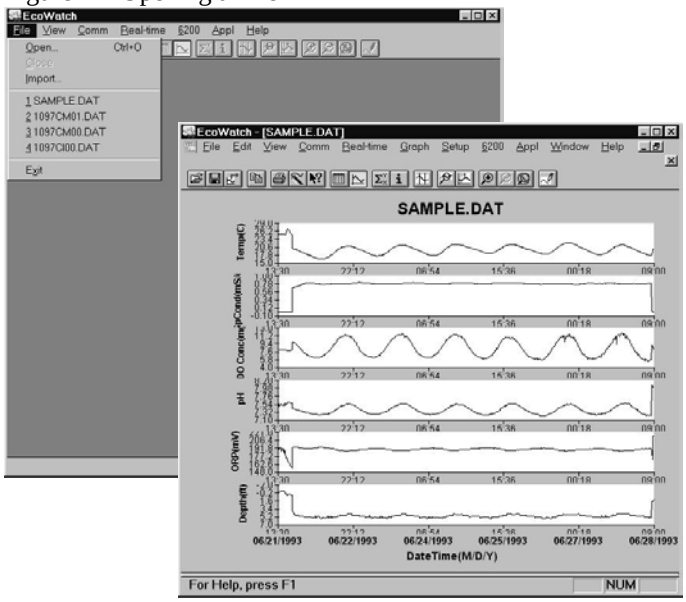
NOTE: In the instructions below that refer to clicking the mouse button, we always refer to the left mouse button unless otherwise specified.

OPENING A DATA FILE

If EcoWatch is not running, open the program by double clicking on the EcoWatch icon. Click on **File** to view a drop-down menu similar to the one shown in Figure 41. From this menu click on **Open**, then locate the drive and directory where SAMPLE.DAT (or your file of interest) resides. Alternatively, if you have been using EcoWatch during setup and checkout, you may be able to click on the file of your choice in the most recently opened files.

Once the SAMPLE.DAT file is open you should see a plot, Figure 41, which graphically represents seven days of sonde data for six different water quality parameters plotted as a function of date and time. Each set of data is autoscaled to allow you to see the minimum and maximum values for each parameter during the one-week study.

Figure 41 Opening a File



Some daily variations may be noticed in parameters such as dissolved oxygen, pH and temperature in this particular study. This is fairly typical in many natural bodies of water. Note also that conductivity is low at both ends of the graph. You may notice similar perturbations in some of the other readings as well. In this example, the sonde was not in the water for a short time at the beginning and end of the study. Not only can you see exactly when the sonde went in and out of the water, but the bottom graph shows the depth at which the sonde was deployed.

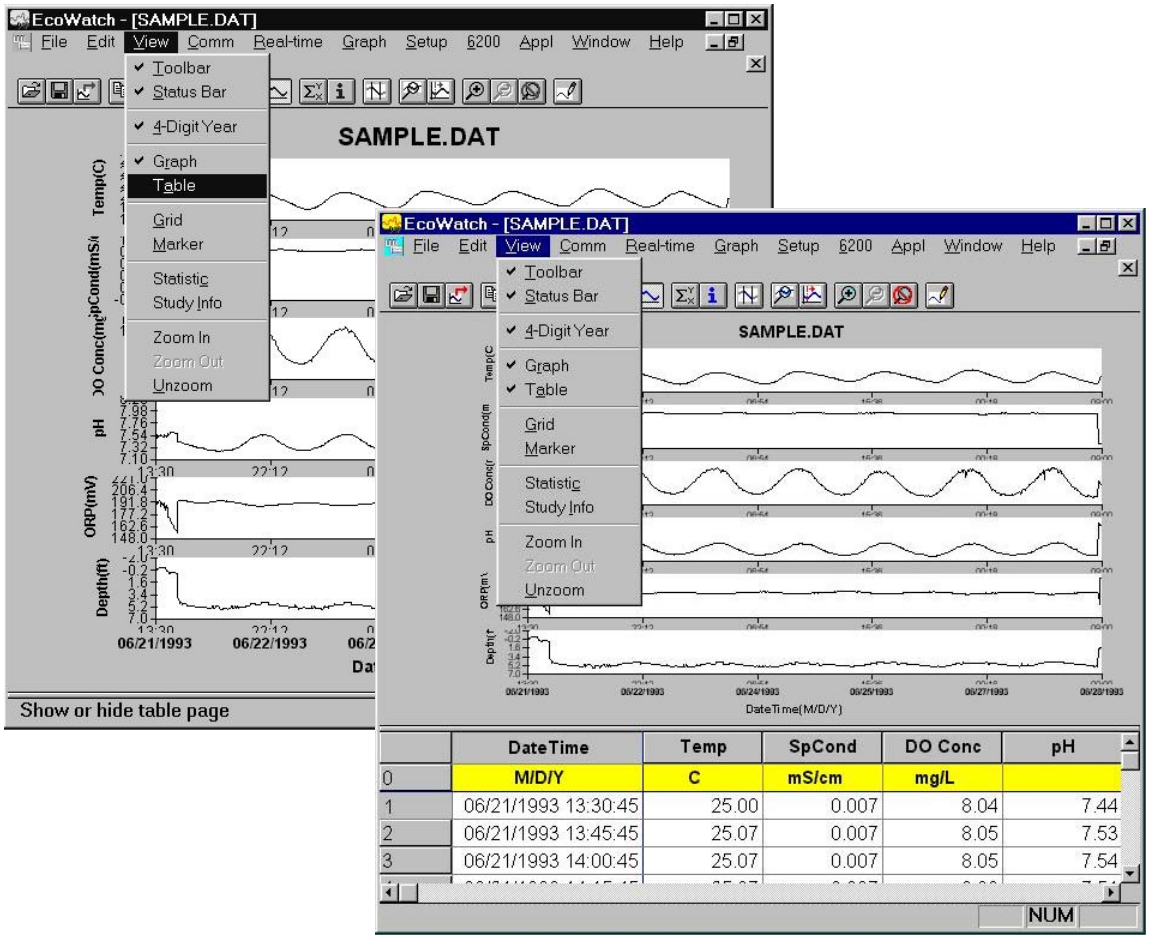
Notice also that you now see a new set of menu items in the top line. Some of these functions are specifically related to viewing and manipulating data. Next we will examine some of the viewing options.

VIEWING DATA

To look at some of the viewing options, click on **View** (Figure 42). Note that the Toolbar and Status Bar are turned on (check mark). In addition, the 4-Digit Year expression is checked. Also note that a check mark is just left of the Graph choice. When a check is next to Graph, all data are expressed graphically in the opening window.

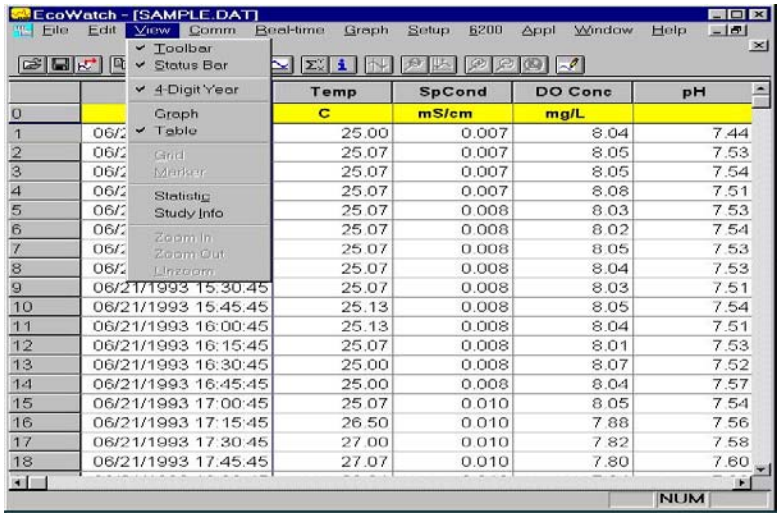
To show data in both graphical and data table format, highlight the Table menu item, then click or press **Enter**. The graphical portion of the window becomes compressed, and the data table becomes visible. If you then click on **View** again, both the Graph and Table items have check marks to their left, indicating that both functions are turned on. You may use your mouse to scroll up/down and left/right to view data.

Figure 42 Viewing Options



It may be somewhat awkward to scan the data table in this manner; therefore you have the option to turn off the graphical representation and allow the table to fill the window. See Figure 43. Notice now that when you click on **View**, the Graph item is no longer checked.

Figure 43 Viewing the Data in Table Format



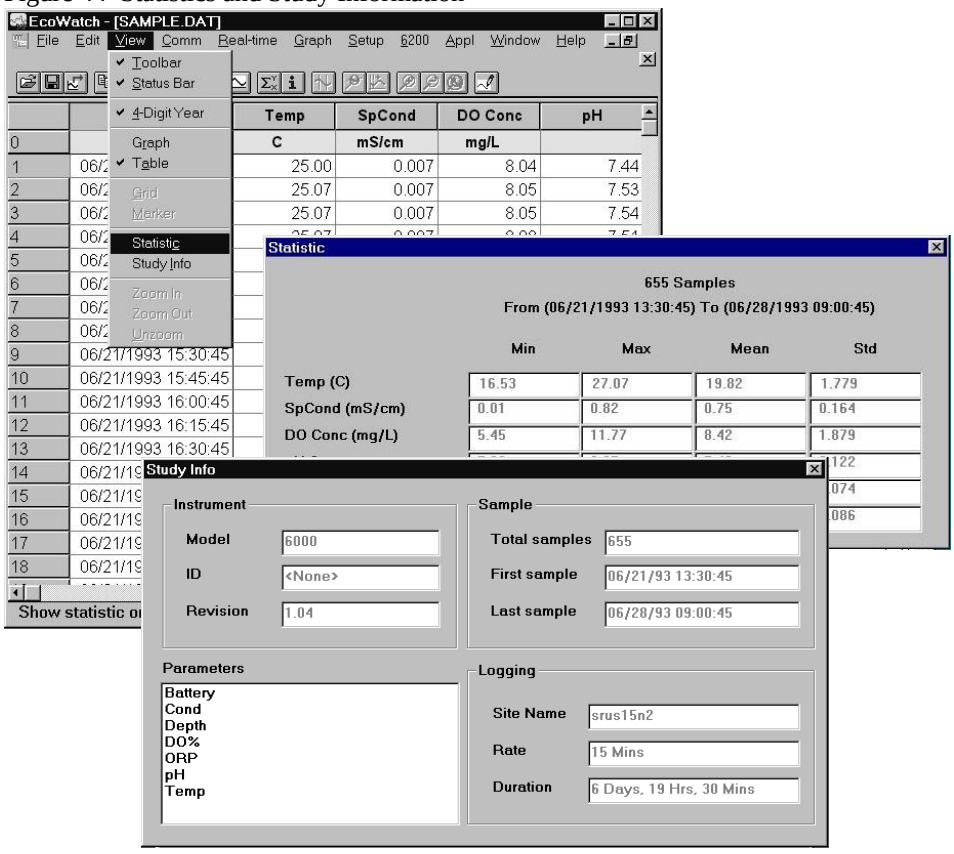
Viewing features such as Grid, Marker, Zoom In, Zoom Out and Unzoom are all available when you activate the **Graph** function. Give each a try as you practice and learn more about the many features of EcoWatch.

The **Statistics** and **Study** functions of EcoWatch are shown in Figure 44. Both provide overview information related to the study data. The **Statistics** function lists minimum, maximum, mean and standard deviation information for each parameter activated. The **Study** function provides useful information about the design of the study including sample interval, date/time, number of samples, sensor identification and parameters reported. The Statistics and Study windows may be activated over either graph or table presentations.

To view either of these windows, click on **View**, highlight the desired function and click again. The window opens on top of the table or graph, similar to what is shown in Figure 43. Only one of these windows may open at one time. To continue, you must close the Statistics or Study window to return to the graph or table and activate the top line menu again.

As before practice viewing the functions mentioned above to gain more familiarity with these features.

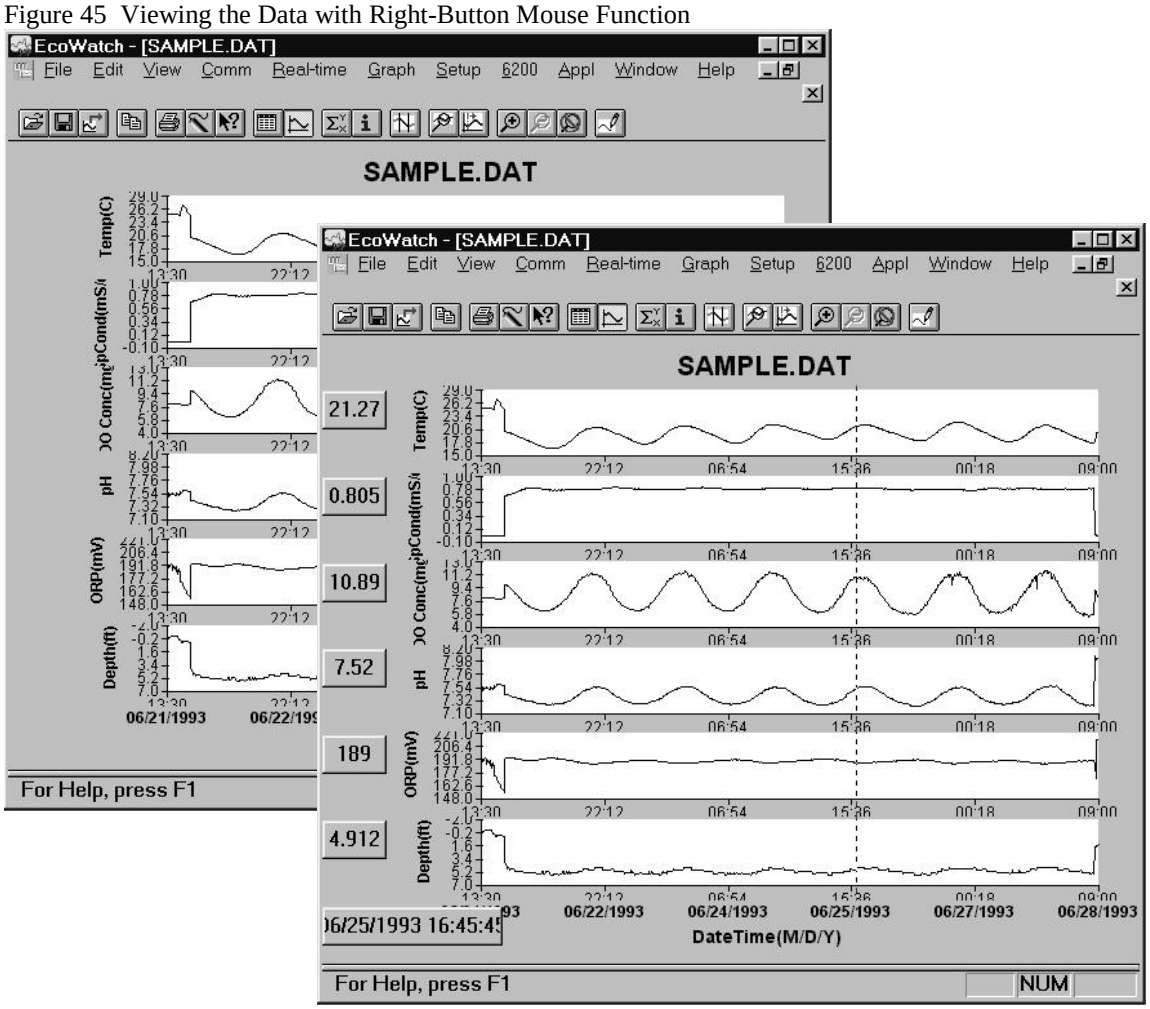
Figure 44 Statistics and Study Information



Next, with the Statistics and Study windows closed, return to the **View** menu, close **Table** and activate **Graph**.

Using the right mouse button, click at any point on the graph. A dotted vertical line appears along with specific data values in boxes to the left of the displayed graphs, as shown in Figure 45. You can hold down the right mouse button and move the mouse to scan the entire graph that is displayed in the window. The values in the boxes change as you move the mouse. This feature is very useful for quantifying specific data without the need to open the data table and scroll through what may be thousands of data points. Note also that the exact time and date change to let you know specifically when an event of interest occurred.

Figure 45 Viewing the Data with Right-Button Mouse Function

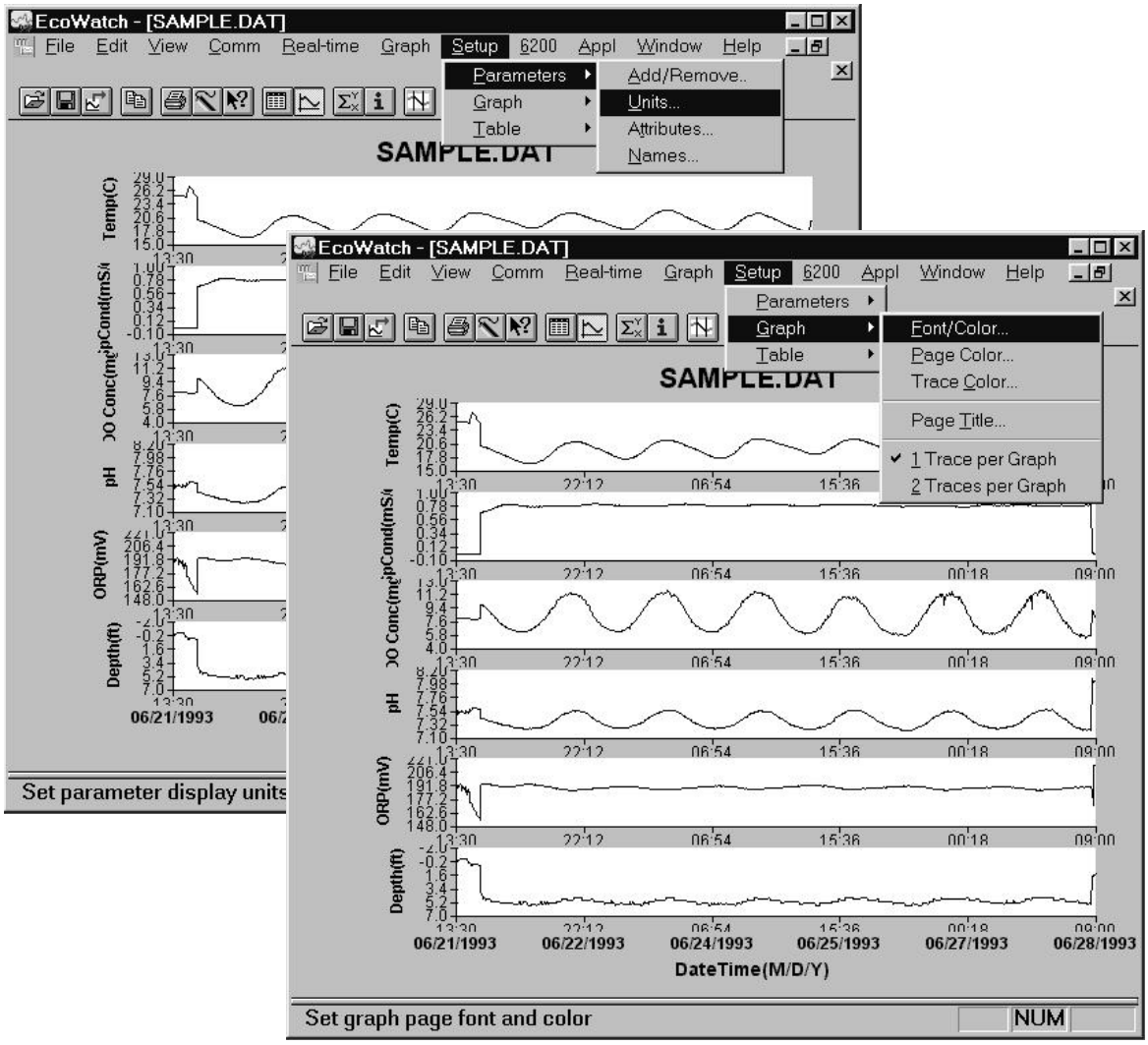


CHANGING DISPLAY FORMATS USING SETUP

Beyond selecting data viewing options such as table format or graphical format, you may also customize your data displays. For example, you may change the order in which parameters are viewed, you may add and delete parameters, you may change plot appearance using different interval times and different units, and you may change the x-axis if you prefer a parameter other than date or time.

The Top Line menu selection that allows you to select some of these parameter changes is **Setup**. Click on **Setup**, then **Parameters**. From here there are four submenus that allow you to Add/Remove parameters, change Units, change sample interval and/or x-axis (Attributes) and change the Names of the parameters you have assigned, as shown in Figure 46.

Figure 46 Changing the Appearance of a Graph or Table



If you are displaying the graph, you may change the appearance by changing font, font style, size and text color. You may also change page color, trace color and graph background color. You may assign a custom 2-line title for the graph, and finally, you may display 1 trace or 2 per set of axes. For display of table formatted results you may change font, font style, size and text color. In addition, you may change table color and highlight color.

The menu structure is easy to follow. Try some changes to gain familiarity with these **Setup** display options.

CHANGING DISPLAY FORMATS USING 'GRAPH' FUNCTION

The top line menu labeled **Graph**, as the name suggests, can be used to examine critical events within the graphical format. You may be able to more clearly understand an event by zooming in/out, centering an event of interest, and setting limits to focus in on a specific area of the graph. In addition to modifying

along the x-axis, you may also manually scale the y-axis. This may allow you to discard a noise spike and obtain better resolution of events unrelated to the noise. Functions like Autoscale, Redraw and Cancel Limits are all used to "undo" some of the customization functions. Below in Figure 47 you see some of these functions.

One very commonly used function is **Limit Data Set**. If you choose this function by clicking on the highlighted item as shown below, you then use the mouse to move your cursor to the left limit of an area of interest, click once, then move the mouse to the right limit of interest and click again. The result will be a close up look at the specific area of the graph you have defined. Refer to Figure 47 and 48 below to see the results of this particular feature.

Figure 47 Selecting a Subset of Data within a Graph

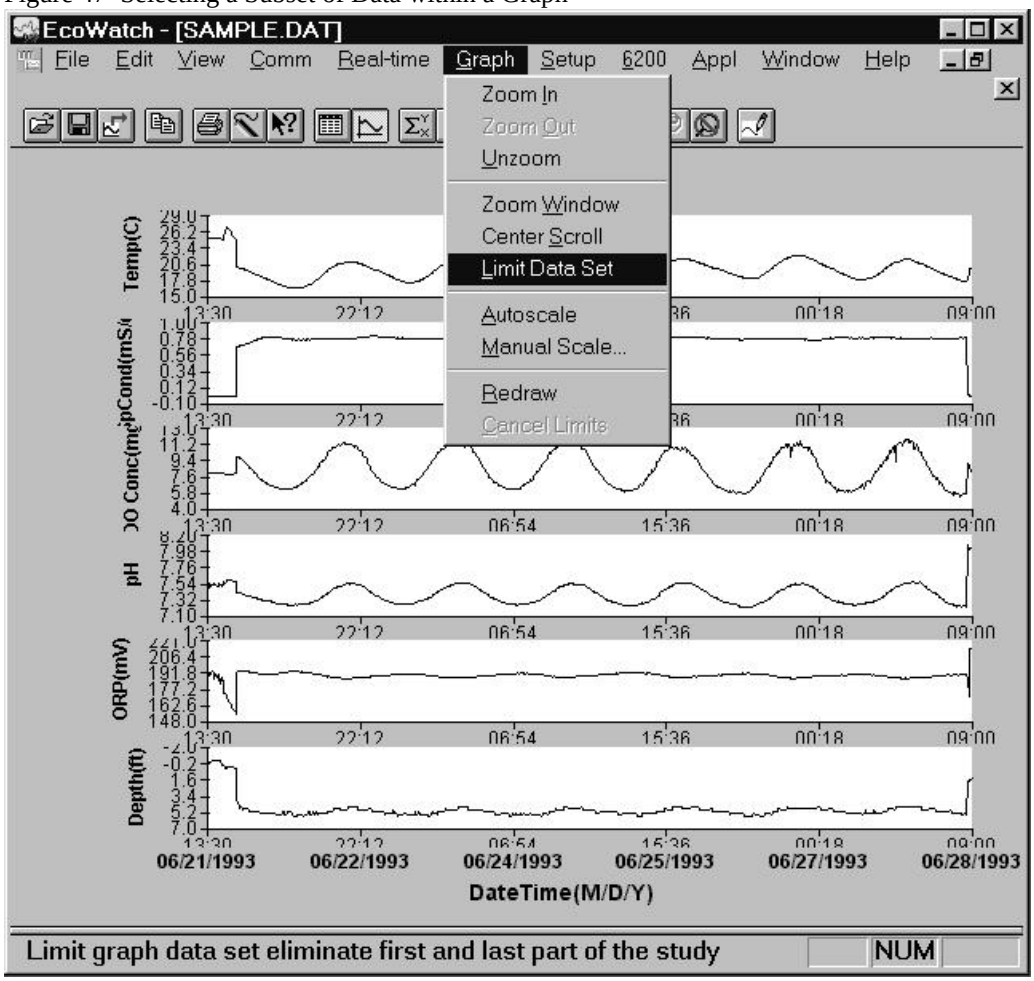
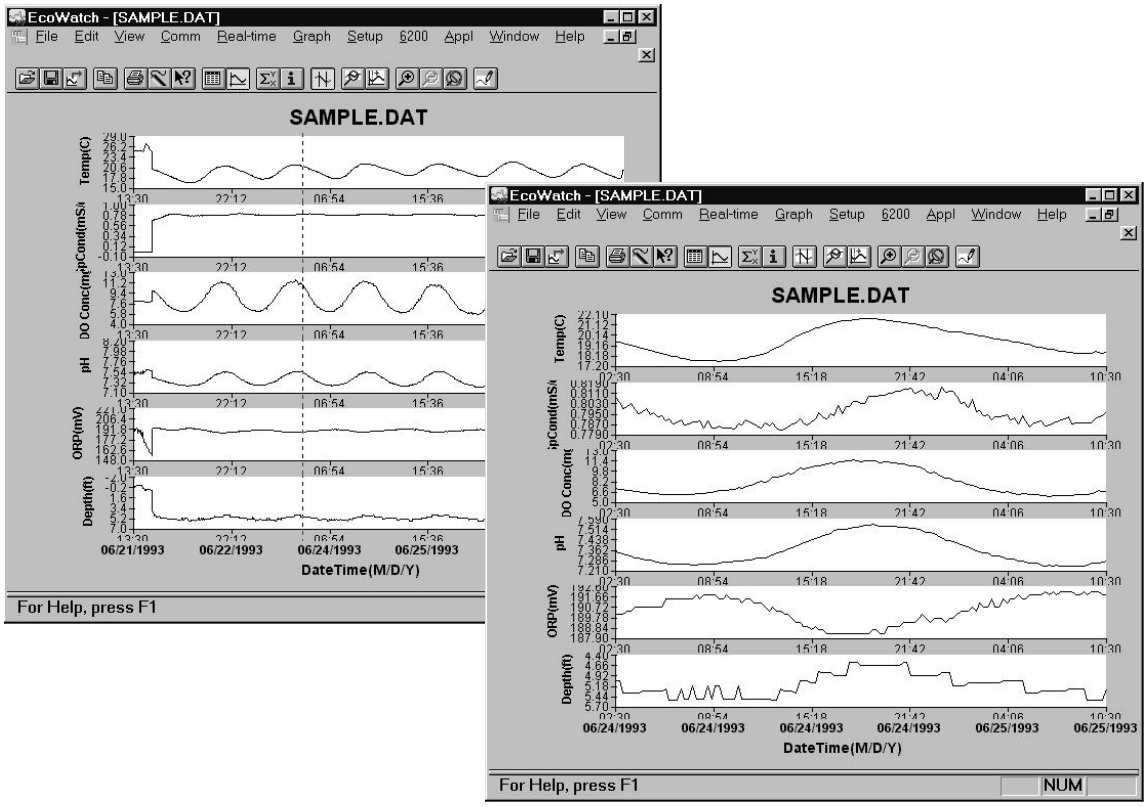


Figure 48 Using Limit Data Set to Display a Subset of Data

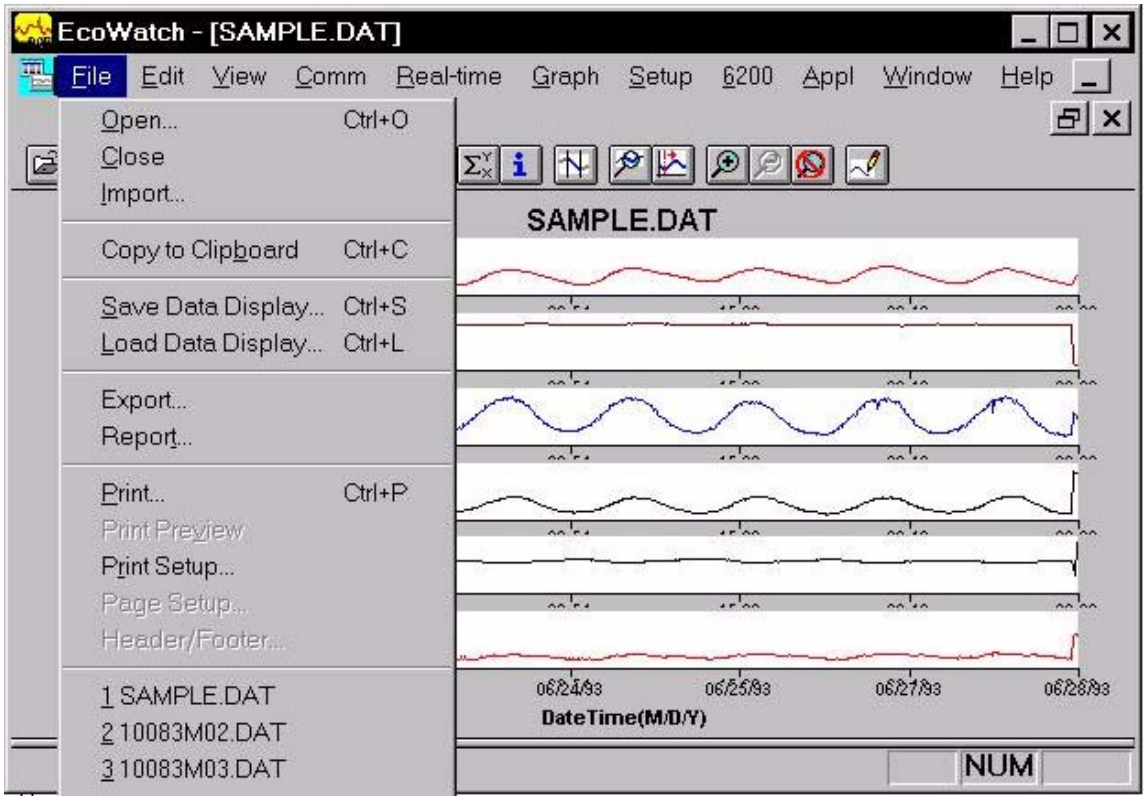


To return to the full set of data again, click on **Graph**, then **Cancel Limits**. If you desire a hard copy of any graph or table, or even a subset expression as shown above, you may use the **Edit, Copy** command to 'copy' the graph in the active window to the "Clipboard". You can then 'paste' this graph to the Windows application program of your choice. You may also be able to print graphs and tables as described in the next section.

SAVE, IMPORT, EXPORT AND PRINT COMMANDS

Under **File** function in the top line menu, you can save a particular presentation version of a data file and give the presentation a customized name. For example, you might want to call the expanded plot in Figure 48 "DIURNAL" using the **File|Save Data Display** command. This presentation will be saved with your data file and can be recalled in further by using the **File|Load Data Display** command. You can also export your custom data display as a spreadsheet compatible file (.CDF or .TXT) or print it to a compatible printer. You may also create a custom report format using **the File|Report** command. See Figure 49 for the **File** menu, which shows these commands. Use the Window's Help function to learn more about these features.

Figure 49 Saving, Exporting, Printing and Related Functions



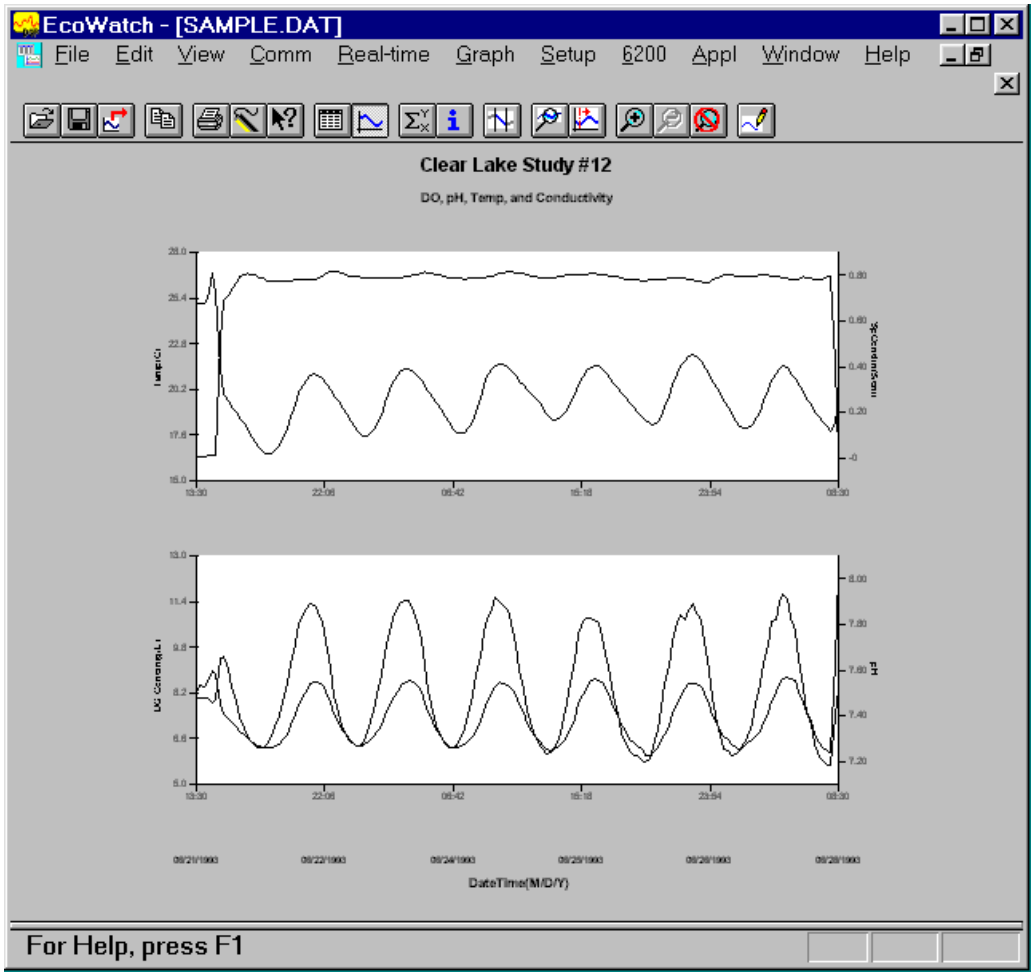
EXAMPLE OF CUSTOMIZING A SUBSET OF SAMPLE.DAT

To conclude this section we have used a few of the many tools available in EcoWatch to demonstrate how you might use this powerful plotting and reporting program to express study results. We encourage you to try some of the tools and learn more about EcoWatch by using the Window's Help function, which is available when the EcoWatch program is running.

Using SAMPLE.DAT we decided that some of the data were not of particular interest, so using top line menu item **Setup**, then Parameters, then **Add/Remove,** we removed ORP and Depth results from the data set. Note that we have not deleted this information from the file, but rather we are choosing not to display it. You can always return to this function and add original data back. Under the same **Parameters** function, we have selected **Attributes** and changed the Average Interval from the default **0** to **60**. Since data was collected every 15 minutes, the change to a 60 minute interval helps to smooth out the graph and average out any short term "noise" events.

Next, we again select **Setup**, then **Graph**. From the functions available, we first selected Title Page… and typed in a name (Clear Lake Study #2) and below that we typed the parameters that are shown in the graph. Just below **Title Page,** we clicked on **2 Traces per Graph**. This combines adjacent parameters which is sometimes useful in parameter and event evaluation. For example, in the second graph shown in Figure 50 below, you see that DO concentration and pH seem to track rather closely and change in a diurnal rhythm. In actuality, when DO levels drop in a natural body of water, CO_2 often builds up forming carbonic acid which leads to lower pH readings. DO rises again during the day due to photosynthesis, CO_2 then falls and pH increases again. The final plot after making these changes in shown in Figure 50.

Figure 50 Customizing a Graph from SAMPLE.DAT



Finally, we selected **File|Save Data Display** and gave the custom plot the name “4PARAM” to that the presentation can be immediately recalled in the future.

As you become more familiar with EcoWatch for Windows, the plotting, analysis and reporting functions can be accomplished easily and quickly. Practice with all of the functions and, again, do not forget to use Window’s Help for more detail, or see Section 4, **EcoWatch for Windows**.

2.9 SONDE MENU

The functions of the sondes are accessible through the sonde menu. The sonde menu structure makes it simple and convenient to select functions. This section provides a description of the menus and their capabilities.

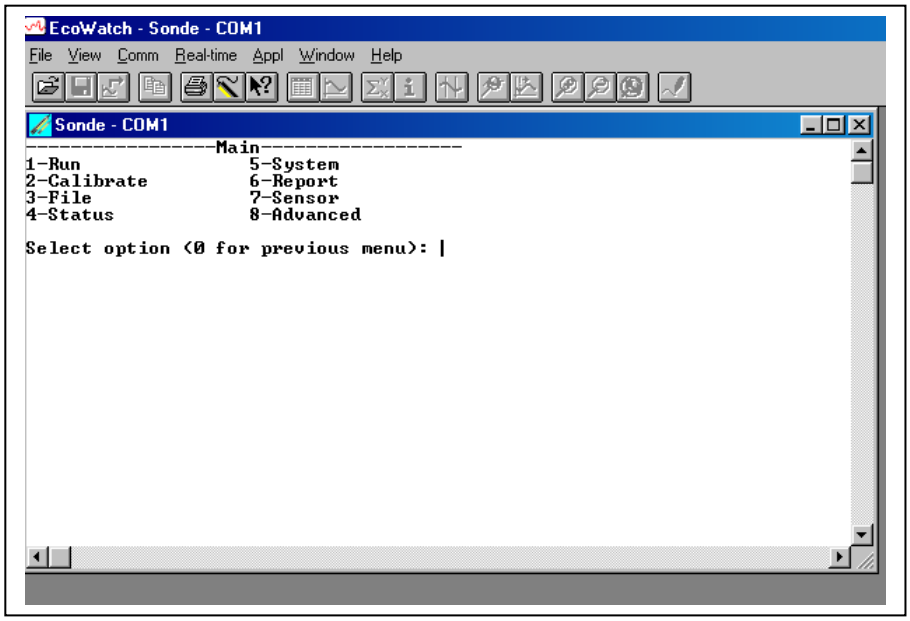
When moving between menus within the sonde software structure, use the **0** or **Esc** to back up to the previous menu. To exit menus and return to the sonde command line (the # sign), press **0 or Esc** until the question "**Exit menu (Y/N)?"** appears. Type **Y** and the command prompt ("#") will be shown. To return to the **Main** sonde menu, type **menu** and press **Enter.**

IMPORTANT MESSAGE!
WHAT IF THERE IS NO RESPONSE TO A KEYSTROKE?

To save power, the sondes will power down automatically if no interaction from the keyboard occurs for approximately 60 seconds. When the software is in this "sleep" mode, the first subsequent keystroke simply "wakes it up" and has no visible effect on the display. The next keystroke after the unit is "awakened" will be input to the software in the intended manner. Thus, if you press a key after the sonde has been inactive for some time and nothing seems to happen, press the key again.

To gain experience with the sonde menus, select the sonde icon in EcoWatch for Windows and press **Enter**. See Figure 40 above for the Sonde Menu Flow Chart.

In the following subsections you will learn about the functions of the various menu items and when to use them. The discussion of the menu and submenu functions is organized in numerical order, beginning with **Section 2.9.1 Run**



2.9.1 RUN

Select **1-Run** from the Main menu to begin taking readings or to set/verify the parameters required for a study. There are two options in the Run menu.

```
---------------Run setup---------------
1-Discrete sample
2-Unattended sample

Select option (0 for previous menu): 1
```

DISCRETE SAMPLING

Discrete sampling is usually used in short term, spot sampling applications when the user is present at the site and the unit is attached to a 650 MDS Display/Logger or laptop PC. It could be used in the vertical profiling of a lake or river where the user lowers the sonde incrementally into the water, and data acquired for a few minutes at each depth. In this section, you will learn how to use the sonde menu structure to open and close files, set the interval between samples, start the sampling operation, and log data to the internal memory of the sonde.

Select **1-Discrete sample** from the Run menu. The Discrete sample menu will be displayed.

```
------------Discrete sample------------
1-Start sampling
2-Sample interval=4
3-File=
4-Site=
5-Open file

Select option (0 for previous menu):
```

Select **1 – Start sampling** option to start discrete sampling. After the initial sampling time interval has passed (4 seconds in the screen above), sequential lines of data will appear on the screen.

```
=========================================================================
   Date     Time  Temp SpCond    Sal  DO     Depth    pH   Turbid  Battery
mm/dd/yy hh:mm:ss     C  mS/cm    ppt  mg/L    feet           NTU   volts
-------------------------------------------------------------------------
*** 1-LOG last sample   2-LOG ON/OFF,  3-Clean optics***
05/05/97 10:04:40 21.57  0.009   0.00  7.73  -0.293  7.55        0.3    10.2
05/05/97 10:04:44 21.57  0.009   0.00  8.41  -0.300  7.55        0.3    10.3
*** LOG is ON,  hit 2 to turn it OFF,  3-Clean optics***
05/05/97 10:04:48 21.58  0.009   0.00  8.41  -0.302  7.55        0.3    10.3
05/05/97 10:04:52 21.58  0.009   0.00  8.40  -0.302  7.55        0.3    10.3
05/05/97 10:04:56 21.58  0.009   0.00  8.41  -0.303  7.55        0.3    10.2
05/05/97 10:05:00 21.58  0.009   0.00  8.42  -0.303  7.55        0.3    10.3
*** 1-LOG last sample   2-LOG ON/OFF ,  3-Clean optics***
05/05/97 10:05:04 21.58  0.009   0.00  8.44  -0.304  7.55        0.3    10.3
Sample logged.
05/05/97 10:05:08 21.58  0.009   0.00  8.45  -0.305  7.55        0.3    10.3
```

The following prompt will appear just below the screen header:
1-LOG last sample, 2-LOG ON/OFF, 3-Clean optics

- By entering **1–LOG last sample**, A single line of data can be logged to sonde memory and the following message will be displayed: **Sample logged.**

- By entering **2-LOG ON/OFF**, a set of data can be logged to memory and the following message will be displayed: **LOG is ON, hit 2 to turn it OFF, 3-Clean optics.** Press **2** again to terminate logging.

- By entering **3-Clean optics**, if your unit has an optical probe, the wiper will clean the optical surface**.** The **3-Clean optics** portion of the prompt will only appear if an optical probe was installed and enabled.

Select **Esc** or press **0** and return to the Discrete Sampling menu.

From the Discrete Sampling menu, select **2-Sample Interval** to type a number that represents the number of seconds between samples. The maximum sample interval is 32767 seconds (9+ hours). The factory default sample interval is 4 seconds and works best for most discrete sampling applications. The shortest possible sample interval for obtaining new DO readings is 4 seconds. If a smaller interval is selected, then the DO readings remain constant for the number of samples necessary to fill 4 seconds.

NOTE: If your have used your sonde with a 650 MDS data logger, the Sample Interval automatically be changed to 0.5 seconds.

Sampling Faster Than 0.5 Seconds

For special applications, your sonde is capable of faster sampling. The only limitation is a reduction of the number of sensors selected. To determine the maximum sampling frequency for your sensor setup, divide 36 by the number of enabled sensors in addition to the DO sensor.

Example:
If you enable any three sensors plus DO, divide 36 by 3 to obtain 12 samples/second (12 Hz) or 0.083 seconds between samples as the maximum sampling frequency. Remember that for sample intervals less than 4 seconds, DO readings are updated only every 4 seconds. Thus, at 12 Hz, the display will show 48 identical DO readings before a change occurs. Note also that at a faster sampling rate, consecutive readings are closer together, the threshold for any one sensor is less likely to be exceeded, and the data filter is less likely to disengage. For these applications you may want to adjust your threshold settings accordingly. See Section 2.9.8 for more information on the data filter.

Select **3-File** to enter a filename with a maximum of 8 characters. You will log readings to the filename that you enter.

If you started sampling without entering a filename, the default name NONAME1 will be assigned to your file. Whenever you press **1-LOG last sample** or **2-LOG ON/OFF** from the menu, NONAME1 will be opened during sampling. If this happens, and you want to restart the file with a different name, press **5-Close file** and rename the file.

Select **4-Site** to assign a site name with a maximum of 31 characters This allows you to enter the name of the site where you are sampling.

When you select **5-Open File**, a file is opened and the number 5 changes to **Close File**. When you are finished logging data to the file, press **5-Close File** and designation changes back to **Open File**. When you start logging the **Open File** designation changes automatically to **Close File**.

Now select **1-Start sampling** to start discrete sampling.

After the initial sampling time interval has passed, sequential lines of data will appear on the screen and you can log single or sequential data points and wipe the surface of your optical probe as described above.

UNATTENDED SAMPLING

This option is used for long-term deployment of the battery-powered sonde when the user is not present at the site. Prior to this selection, the sonde is usually attached to a computer in a laboratory and set up to automatically log data to sonde memory at a fairly long time interval (15-60 minutes). The unit is then taken to the field site and left for an extended time period (from 30 up to 150 days depending on the sensors used and the fouling conditions). When the study is complete, or the batteries are expended, the unit is brought back to the laboratory and the data file is uploaded to a computer. Quality assurance checks are performed prior to redeployment.

Select **2-Unattended Sampling** from the Run menu. The Unattended sample menu will be displayed. Use the following example to understand the unattended sampling option.

```
------------Unattended setup----------
1-Interval=00:15:00
2-Start date=07/17/96
3-Start time=18:00:00
4-Duration days=14
5-File=clrlake3
6-Site=Clear Lake at Spillway
7-Bat volts: 9.1
8-Bat life 21.2 days
9-Free mem 18.9 days
A-1st sample in 8.10 minutes
B-View params to log
C-Start logging
```

Follow the prompts on this screen to prepare your sonde for unattended deployment as described below:

- Verify that the current time and date are correct to ensure that your unattended sampling study begins and ends when you desire. To verify correct the time and date, return to the Main menu and enter **4-Status** or **5-System**. You may enter the correct date and time from either of these submenus.

- Select **1-Interval** and enter the desired time between samples

- Select **2-Start Date** and **3-Start Time** to set the time that data will begin to log to sonde memory. . Use the 24-hour clock format to enter the time. If you do not make any change to these entries, then the study will automatically begin at the next integral time interval once you have pressed **C-Start logging**.

  Example: If the current time is 17:20:00 and your sample interval is 15 minutes, logging will automatically begin at 17:30:00.

It is better to start the study prior to taking the unit to the field so that you can confirm that readings are being saved to memory and carry out initial quality assurance. However, if your study demands that you start the instrument at the site at 6:00 PM, change the Start Time to 18:00:00.

- Select **4-Duration** and set the length of the study in days. The default value is 365 days (which is longer than most deployments). In most cases, you will either want to stop the unattended study manually or allow the batteries to be expended. It is wise to set the duration to a value longer than the anticipated deployment. If you cannot retrieve the sonde at the expected time due to factors beyond your control such as weather or illness, data will continue to be acquired as long as battery power is present.

- Select **5-File** and enter a name of no more than 8 characters that will be used by your external computer to identify the study. Be sure to use ONLY alpha/numeric characters.

- Select **6-Site** and enter a site name of no more than 31 characters. This filename will appear in your sonde file directory, but will not be used to identify the file after transfer to your computer.

- Check **7-Battery** to make certain that the voltage is suitable for the length of the study that you are about to begin. No change can be made to this item via the software. Note that no battery entry will appear for the 600R, 600QS, 600XL, and 6820V2-1 sondes.

- Select **B-View Parameters to log** to confirm that your sensor and report setups are configured correctly as described in Sections 2.9.6 and 2.9.7. An example screen is shown below.

```
-------------Params to log-------------
1-Temp C            6-Orp mV
2-Cond mS/cm        7-NH4+ N mg/L
3-DOsat %           8-NO3- N mg/L
4-DOchrg            9-Turbid NTU
5-pH                A-Battery volts

Select option (0 for previous menu):
```

In some cases, the **View params to log** screen only identifies the raw parameters that are used in the calculation of the items that you have selected in the Report setup.

> **Example:** You have selected DO mg/L in the Report setup, but it does not appear under **View parameters to log** because it is calculated from DO saturation %,Temperature, and Conductivity. Likewise, although specific conductance is selected in the Report setup, it does not appear under **Parameters to log** because it is calculated from Conductivity and Temperature. In all but a few cases, the proper configuration of **Parameters to log** will be automatically set up as long as the sensor is enabled.

There are several items that must be activated in the Report setup so they will be available from the file after upload. These special parameters are: DO Chg, DOSat %Local, ODOsat %Local, pH mV, $NH4^{+}$ mV, $NO3^{-}$ mV, Cl^{-}mV, PAR1, PAR2, Chl RFU, BGA-PC RFU, and BGA-PE RFU. If you want to log any of these parameters to your data file, be certain that they are active in the Report setup before you begin the unattended study.

After making the above entries, the sonde software will automatically estimate the expected battery life, and the time it will take for the sonde memory to be filled. This information is displayed on the screen for your consideration. If the battery life or the free memory capacity will be exceeded sooner than the duration, you may want to make some changes to the sonde set-up or the batteries themselves. For example, you can free up memory in the sonde by uploading all existing files from the sonde memory to your PC and then deleting them from the sonde (see **3-File** from Main Menu). You may want to change the batteries for longer battery life. You can lengthen the sampling interval to extend both battery life and memory capacity.

The predicted battery life is an estimate only. The temperature of the site and the brand of batteries used can affect battery life. It is recommended to recover the sonde earlier than the predicted battery life, and to use new batteries for each deployment.

Once you press **C-Start logging**, the following screen will appear.

```
-------------Start logging-------------
Are you sure?
1-Yes
2-No

Select option (0 for previous menu):
```

Select **1-Yes** and the screen will change.

```
----------------Logging----------------
1-Interval=00:15:00
2-Next at 07/17/96
3-Next at 18:00:00
4-Stop at 07/31/96
5-Stop at 18:00:00
6-File=clrlake3
7-Site=Clear Lake at Spillway
8-Bat volts: 9.0
9-Bat life 21.2 days
A-Free mem 18.9 days
B-Stop logging
C-Show Live Data

Select option (0 for previous menu):
```

The display now shows the next date and time for logging and the stop date and time for the logging study. Most importantly, note that the bottom command now shows **B-Stop logging**, a confirmation that the logging has indeed been initiated.

If you select **C-Show Live Data** and leave the sonde attached to your PC, the data points will be shown on the screen as they are stored to internal memory.

The Unattended study will terminate when the duration you specified has expired or the batteries are expended. If you want to terminate sooner, simply select **2-Unattended** sample from the Run menu, then **B-Stop logging**. Select **1-Yes** and return to the Unattended setup menu.

```
Stop logging?
1-Yes
2-No

Select option (0 for previous menu):
```

2.9.2 CALIBRATE

All of the sonde sensors (except temperature) require periodic calibration to assure high performance. However, the calibration protocols for Rapid Pulse Polarographic dissolved oxygen are significantly different depending on whether the sonde is being set up for spot sampling or longer term unattended monitoring studies. This difference is user-selectable and is required primarily because the optimal performance of the Rapid Pulse dissolved oxygen sensor cannot be attained unless the control of this sensor varies from short term to long term applications.

For spot sampling it is best to pulse the sensor continuously during the **Run** mode to attain the most accurate results and optimize the response time. However, this continuous pulsing is not ideal for longer term logging studies in which the sonde data is captured to sonde memory or to a data collection platform at much less frequent intervals (e.g. 15 minutes). Continuous pulsing not only shortens the time between required probe maintenance, but consumes more power. With proper selection of the "Auto sleep" option (discussed in detail in **Section 2.9.8, Advanced Menu**), the user can configure the sonde software to either run continuously or "go to sleep" between samples to minimize Rapid Pulse DO probe wear and conserve power. The effect of this choice on the user interface relative to dissolved oxygen calibration is significant as described below:

- If "Auto sleep" is **deactivated**, the sonde runs continuously no matter what sample interval has been selected. Under these conditions, the user retains manual control of the dissolved oxygen calibration routine, viewing the stabilization of the readings in real time and confirming the calibration with keyboard entries.

- If "Auto sleep" is **activated**, the sonde will 'warm up' the sensors for the period of time selected for the DO sensor. Under these conditions, the user loses manual control of the Rapid Pulse DO calibration routine. Rapid Pulse DO will automatically calibrate after the selected time for warm up of the DO sensor has expired. In this mode of calibration, you do not observe stabilization of the readings in real time, but instead will observe a countdown of the warm up period followed by a message indicating that the Rapid Pulse DO calibration is complete.

Only the calibration of Rapid Pulse dissolved oxygen is affected by whether "Autosleep" is on or off; the user retains manual control of the calibration of all other parameters regardless of the "Auto sleep" setting. Once a particular warm up time (in seconds) has been utilized in Rapid Pulse DO calibration, the length of that time should not be changed during a study. A new calibration should be performed whenever the value of the warm up time is altered.

Note that the ROX Optical DO sensor is not subject to the above issues relative to the activation of "Autosleep RS232" for the Rapid Pulse DO sensor. The ROX sensor calibrates in the same way as any other sensor such as conductivity, pH, or turbidity where the user manually confirms the calibration after the sensor readings have shown stability.

From the Main sonde menu select **2-Calibrate**. The Calibrate menu will be displayed. Only the enabled parameters will be available for calibration.

```
---------------Calibrate--------------
1-Conductivity      6-ISE3 NH4+
2-Dissolved Oxy     7-ISE4 NO3-
3-Pressure-Abs      8-ISE5 Cl-
4-ISE1 pH           9-Optic T-Turbidity 6136
5-ISE2 ORP          A-Optic C - Chlorophyll

Select option (0 for previous menu):
```

CONDUCTIVITY

Select **1-Conductivity** to calibrate the conductivity probe and a second menu will offer you the options of calibrating in specific conductance, conductivity, or salinity. Calibrating any one option automatically calibrates the other two. After selecting the option of choice (specific conductance is normally recommended), you will be asked to enter the value of the standard used during calibration. Be certain that the units are correct. After pressing **Enter**, you will be able to follow the stabilization of the readings and confirm the calibration when the readings are stable by pressing **Enter** as instructed on the screen. Then, as instructed, press **Enter** again to return to the Calibrate menu.

RAPID PULSE POLAROGRAPHIC DISSOLVED OXYGEN WITH AUTOSLEEP ON

If you intend to do Unattended Sampling, it is recommended that you turn Autosleep RS232 "on" in the Advanced|Setup menu and follow these instructions for DO calibration. If you intend to do Discrete Sampling, it is recommended that you turn Autosleep RS232 "off" and use the calibration instructions in the next section.

Select **2-Dissolved oxygen** to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor shows stable readings prior to beginning the calibration routine, particularly after a membrane change. Note, however, that the sensor should be "off" for at least 5 minutes before initiating a calibration procedure with "Autosleep" active. If possible, it is ideal that the sensor be "off" for a time equal to the sample interval in the upcoming study.

Remember, the Calibration Cup is designed to be air-tight and must be loosened if it is used as a calibration chamber. See **Section 2.6, Calibration** for more details. Follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and the calibration will automatically occur after the warm-up time which has been selected by the user (default is 40 seconds). Then, as instructed, press **Enter** again to return to the Calibrate menu. Note that at calibration, the DOsat % (percent air saturation) value will reflect the barometer value that was entered. For example, if a barometric pressure of 720 mm is entered, the DOsat % value will change to 94.7 % (720/760 x 100).

Note that the parameter "DOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. The key factor to remember, however, is that no matter which convention (DOsat % or DOsat %Local) is selected, the mg/L value will not be affected.

For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will be carried out automatically as for the percent saturation mode above.

RAPID PULSE DISSOLVED OXYGEN WITH AUTOSLEEP OFF

If you intend to do Discrete Sampling, it is recommended that you turn Autosleep "off" in the Advanced|Setup menu and follow these instructions for DO calibration. If you intend to do Unattended Sampling, it is recommended that you turn Autosleep "on" and using the calibration instructions in the preceding section.

Select the **Dissolved Oxygen** option from the **Calibrate** menu to calibrate the oxygen probe. The submenu will offer you the option of calibrating in percent saturation or mg/L. After selecting the option of choice (percent saturation in water-saturated air is normally recommended), you will be prompted for the next step. Calibrating either of the choices will automatically calibrate the other.

For the percent saturation mode, be certain that the sensor has been thermally equilibrated in water-saturated air and that the sensor has stabilized prior to beginning the calibration routine, particularly after a membrane change. Relieve pressure in the cup if necessary. Remember, the Calibration Cup is designed to be air-tight and must be loosened if used as a calibration chamber. Then follow the screen prompt and enter the local barometric pressure in mm Hg, (inches Hg x 25.4), press **Enter**, and monitor the stabilization of the DO readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press Enter again to return to the **Calibrate** menu. Note that at calibration, the DOsat % (percent air saturation) value will reflect the barometer value that was entered. For example, if a barometric pressure of 720 mm is entered, the DOsat % value will change to 94.7 % (720/760 x 100).

Note that the parameter "DOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. The key factor to remember, however, is that no matter which convention (DOsat % or DOsat %Local) is selected, the mg/L value will not be affected.

For the mg/L mode, calibration is carried out in a water sample which has a known concentration of dissolved oxygen, usually determined by a Winkler titration. For this calibration procedure, the sensor should be immersed in the water. After thermal equilibration, enter the known mg/L value, press **Enter**, and the calibration procedure will begin with similar viewing of stabilization and confirmation of calibration as for the percent saturation mode above.

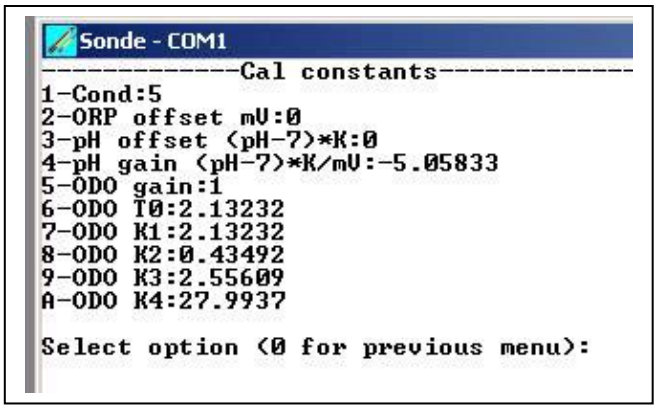
NOTE: If you have resurfaced your DO sensor, we recommend running the probe continuously for 15-30 minutes or until good stability is realized. After only a membrane change (no resurfacing), run the probe continuously for 3-4 minutes or until good stability is realized.

ROX OPTICAL DISSOLVED OXYGEN

Understanding the Factory Calibration of the ROX Optical DO Sensor

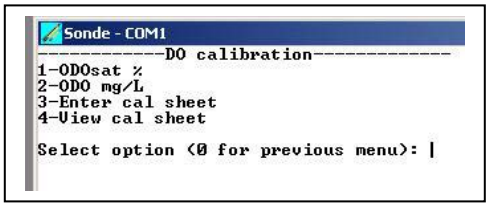
Unlike all other sensors for YSI 6-series sondes, the response of the ROX Optical DO sensor is not linear relative to the species being measured. This non-linearity requires that the sensor be factory-calibrated at a number of oxygen values and the data fit to a third-order regression. The three constants and the sensor value at zero dissolved oxygen which define this regression analysis are automatically stored in the sensor at the time of factory-calibration. It is important to note that these constants are a function of the sensor

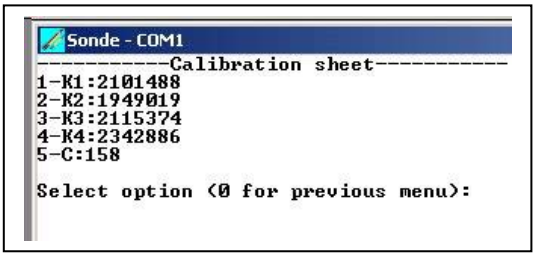
membrane installed on the 6150 probe and NOT a function of the probe, i.e., the constants reflect the characteristics of the sensor membrane and NOT the probe. When a 6150 probe is purchased from YSI, it already has a sensor membrane installed and the constants of that membrane are transferred automatically to the sonde PCB when the sensor is run for the first time. After transfer, the constants can be viewed by accessing the **Advanced|Cal Constants** menu as shown below – the regression constants are ODO K2-ODO K4 and the value at zero oxygen is K1 as shown below.



It should also be noted that the ROX sensor is characterized by two additional parameters – ODO Gain and Tzero. The ODO gain reflects the small change in the calibration which is carried out be the user in a 1-point calibration as described below. The Tzero value will always be the same as K1 until the user elects to perform a 2-point calibration as described below at which time it will change slightly to reflect the adjustment of the zero oxygen value.

You will also note that a different set of constants for your specific sensor membrane are supplied on the instruction sheet which came with your 6150 probe. These five constants (K1-K4 and C) have a different appearance than those shown in **Advanced|Cal Constants** because they are in coded form to allow error-free reentry by the user in the unlikely event that the regression constants in the probe are lost. The C constant is a check sum value associated with the values of K1-K4 and will prevent acceptance of the constants if typographical errors are made in their entry by the user. The coded constants must be entered in the **Calibrate|Optic X – Dissolved Oxy|Enter Cal Sheet** as shown below. The constants can also be viewed at any time by selecting **Calibrate|Optic X – Dissolved Oxy|View Cal Sheet.**





YSI recommends that your replace your sensor membrane after 1 year of use by purchasing the 6155 Optical DO Membrane Replacement Kit. This kit will be supplied with a new set of coded constants which characterize the new membrane and they MUST be entered via the **Calibrate|Optic X – Dissolved Oxy|Enter Cal Sheet** selection as show above. Once the new constants have been entered in coded form they will be transferred to the probe and will be visible in uncoded form in Advanced|Cal Constants.

See **Section 5.9, Principles of Operation** and **Appendix M, ROX Optical DO Sensor** for more information.

User Calibration of the ROX Optical DO Sensor

NOTE CAREFULLY: As opposed to the 6562 Rapid Pulse Polarographic DO sensor described above, there is no difference between the calibration routine for sensors which will be used for sampling or monitoring applications. Usually the Autosleep RS-232 feature in the **Advanced|Setup** menu will be activated for ROX calibrations, but there is no problem if it is not active.

Select the **Optic X-Dissolved Oxy** option from the **Calibrate** menu to calibrate the oxygen probe. The submenu will offer you the option of calibrating in either percent air-saturation (ODOsat %) or oxygen concentration (ODO mg/L) units. Calibrating either of the choices will automatically calibrate the other. After selecting the option of choice (ODOsat % in water-saturated air or air-saturated water is normally recommended), you will be prompted for the next step where you must elect to do either a 1-point or a 2-point calibration. Except under unusual circumstances as described below, you should select the 1-point option for the ROX Optical DO calibration.

Calibration Using Percent Air Saturation – 1-Point

NOTE: YSI recommends that you use this method for calibration of your 6150 Dissolved Oxygen Sensor to obtain the maximum accuracy under normal operating conditions.

Place the sensor either (a) into a calibration cup containing about 1/8 inch of water which is vented by loosening the threads or (b) into a container of water which is being continuously sparged with an aquarium pump and air stone. Wait approximately 10 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

Select **ODOsat %** and then **1-Point** to access the DO calibration procedure. Calibration of your Optical dissolved oxygen sensor in the DO % procedure also results in calibration of the DO mg/L mode and vice versa.

Enter the current barometric pressure in **mm of Hg.** (Inches of Hg x 25.4 = mm Hg).

Note: Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

True BP = [Corrected BP] – [2.5 * (Local Altitude in feet above sea level/100)]

Press **Enter** and the current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODOsat %. When they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the **Calibrate** menu.

The minor advantages and disadvantages of calibration in air-saturated water versus water-saturated air are outlined in **Appendix M, ROX Optical DO Sensor**

Calibration Using mg/L – 1-Point

Place the sensor in a container which contains oxygen of a known concentration of dissolved oxygen in mg/L AND THAT IS WITHIN +/- 10% of AIR SATURATION as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated, or
- Measurement with another instrument.

CAUTION: Carrying out DO mg/L calibrations at values outside the range of +/- 10 % of air saturation is likely to compromise the quoted accuracy specification of the 6150 Optical DO Sensor.

Wait approximately 10 minutes before proceeding to allow the equilibration of the temperature and oxygen sensors.

Select **ODO mg/L** and then **1-Point** to access the mg/L calibration procedure. Calibration of your optical dissolved oxygen sensor using the DO mg/L procedure also results in calibration of the ODOsat % mode and vice versa.

Enter the known mg/L concentration and press **Enter**. The current values of all enabled sensors will appear on the screen and change with time as they stabilize. Observe the readings under ODO mg/L and, when they show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the **Calibrate** menu.

2-Point Calibrations

By selecting either **ODOsat %** and then **2-Point** or **ODO mg/L** and then **2-Point** from the appropriate menus, you will be able to calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water (if you select **ODO%)** or at zero oxygen and a known concentration of oxygen within +/-10% of air-saturation (if you select **ODO mg/L).** These two-point calibrations should be done ONLY if you suspect that your 6150 Optical DO sensor is less accurate than you require at low oxygen values. The key to performing a 2-point calibration is to make certain that your zero oxygen medium (probably either nitrogen gas or an aqueous solution of sodium sulfite at a concentration of approximately 2 g/L) is truly oxygen-free as described in the tips below:

- If you use nitrogen gas for the zero point calibration, you should make certain that the vessel you use has a SMALL exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.

- If you use sodium sulfite solution for the zero point calibration, you should make up the solution at least 2 hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. You should also transfer the sodium sulfite solution rapidly from its container to the sonde calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the calibration cup to the sonde to prevent diffusion of air into the vessel.

To implement the 2-point calibrations, place the 6150 and the temperature sensor in a zero oxygen medium. Then sel**ect** either **ODO%** and then **2-Point** or **ODO mg/L** and then **2-Point** from the **Calibrate|Optic T Dissolved Oxy** menu. For either calibration routine, you MUST ENTER ZERO at the first prompt asking

for ODO in mg/L. Then view the readings in real time and when they are stable, press **Enter** to confirm the zero point calibration.

CAUTION: Be certain that you wait at least 10-12 minutes and until the readings are stable for at least 2 minutes before confirming the zero point calibration entry.

NOTE CAREFULLY: If you used sodium sulfite solution as your zero calibration medium, you MUST carefully remove all traces of the reagent from the probes prior to proceeding to the second point. YSI recommends that the second calibration point be in air-saturated water if you use sodium sulfite solution as your zero oxygen medium.

After confirming the zero point calibration, place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Then enter either the barometer reading in mm Hg (for **ODO% 2-Point** calibrations) or the actual concentration of oxygen which was probably determined from a Winkler titration (for **ODO mg/L 2-Point** calibrations). Press **Enter** and observe the readings in real time until they are stable. Then press **Enter** again to confirm the calibration. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to return to the **Calibrate** menu.

CAUTION: Carrying out DO mg/L calibrations at values outside the range of +/- 10 % of air saturation for the second calibration point in the 2-Point routine is likely to compromise the quoted accuracy specification of the 6150 Optical DO Sensor.

NOTE CAREFULLY: It will normally not be necessary to perform 2-Point calibrations for the 6150 Optical DO Sensor and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen free.

Note that the parameter "ODOsat %Local" is also available for users who prefer to set their percent air saturation value to 100%, no matter what barometer value is entered. The method of activating this parameter, its use, and its limitations are described in **Appendix J** of this manual. The key factor to remember, however, is that no matter which convention (ODOsat % or ODOsat %Local) is selected, the mg/L value will not be affected.

PRESSURE – ABS AND GAGE

Select **Pressure – Abs (non-vented) or Gage (vented)** to zero the depth sensor. The depth sensor is factory calibrated, but it is always necessary to zero the absolute sensor relative to the local barometric pressure. A minor correction is also sometimes necessary to set the Gage (vented) sensor output to exactly 0.000 feet or meters. The zeroing procedure should be carried out with the sonde in air for this initial calibration. Alternatively, you may set zero or an offset while the sonde is submersed for "relative depth" applications. After the depth option is selected, enter 0.00 (or other appropriate value in feet or meters depending on your Report setup) at the prompt, press **Enter** and monitor the stabilization of the depth readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. As instructed, press **Enter** again to return to the Calibrate menu.

Zeroing the depth sensor by the above protocol (entering 0.00 at the screen prompt) will result in a measurement of the distance between the water surface and the ports of the depth module. In order for the observed depth readings to reflect the distance between the water surface and the actual probe array, measure the length between the upper hole and the bottom of the sonde guard. Then, if you are concerned about this small difference, enter the measured difference (in feet or meters depending on your Report setup) at the screen prompt instead of 0.00.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

pH

When selecting **ISE1 pH**, you will be given the choice of 1-point, 2-point, or 3-point calibrations.

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. Immerse the sonde in a buffer of known pH value and press **Enter.** You will be prompted to type in the pH value of the solution.

NOTE: The actual pH value of all buffers is somewhat variable with temperature and that the correct value from the bottle label for your calibration temperature should be entered for maximum accuracy. For example, the pH of YSI "pH 7 Buffer" is 7.00 at 25 C, but 7.02 at 20 C.

After inputting the proper pH value for your calibration temperature, press **Enter** again, and the screen will display real-time readings that will allow you to determine when the pH and temperature readings have stabilized. Pressing **Enter** will confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu. This calibration procedure adjusts only the pH offset and leaves the previously determined slope unaltered.

Select the **2-point** option to calibrate the pH probe using only two calibration standards. In this procedure, the pH sensor is calibrated using a pH 7 buffer and a pH 10 or pH 4 buffer depending on your environmental water. A two point calibration procedure (as opposed to a 3-point procedure) can save time if the pH of the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is appropriate. Three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.

To begin the calibration, immerse the sonde in one of the buffers and enter the actual pH value depending on your calibration temperature. Press **Enter**, and the screen will display real-time readings that will allow you to determine when the pH sensor has stabilized. Pressing **Enter** will confirm the calibration. Following the instructions on the screen, place the sonde in the second pH buffer, input the pH value, press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

Select the **3-point** option to calibrate the pH probe using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer to complete the 3-point procedure.

ORP

Select **ISE2 ORP** to calibrate the ORP sensor. Immerse the sonde in a solution with a known oxidation reduction potential value (we recommend Zobell solution) and press **Enter.** You will be prompted to enter the ORP value of the solution. Press **Enter**, and monitor the stabilization of the ORP and temperature readings. After no changes occur for approximately 30 seconds, press **Enter** to confirm the calibration. Then, as instructed, press **Enter** again to return to the Calibrate menu.

AMMONIUM

When selecting **ISE3-NH4+,** you will be given the choice of 1-point, 2-point, or 3-point calibrations for your ammonium (NH_4^+) sensor.

Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by doing a one point calibration. Immerse the sonde in any solution of known ammonium concentration and press **Enter.** You will be prompted to type in the NH_4^+ value (in mg/L of NH_4-N) of the solution you are using. Press **Enter** again, and the screen will display real-time readings that will allow you to determine when the $NH4^+$ readings have stabilized. Pressing **Enter** will confirm the calibration.

Select the **2-point** option to calibrate the NH_4^+ probe using only two calibration standards that are both at approximately the temperature of your environmental sample. In this procedure, the NH_4^+ sensor is usually calibrated using solutions that contain 1 and 100 mg/L of NH_4-N . Be certain that the calibration solution and sensor are thermally equilibrated prior to entering NH_4^+ values.

To begin the calibration immerse the sonde in the 1 mg/L standard, press **Enter**, input the NH_4-N value, and again press **Enter.** The screen will display real-time readings that will allow you to determine when the sensor has stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second NH_4^+ standard, press **Enter**, input the correct concentration value, again press **Enter**, and view the stabilization of the values on the screen in real time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option to calibrate the NH_4^+ probe using three calibration solutions, two at ambient temperature and one at a temperature significantly different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure. Be certain that the calibration solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 100 mg/L standard at ambient temperature, (2) 1 mg/L standard at ambient temperature, and (3) 1 mg/L standard at a different temperature (usually lower) than ambient. For best results, insure a temperature difference of at least 10 C° between the two 1 mg/L standards.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

NITRATE

When selecting **ISE4 NO3**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your nitrate (NO_3^-) sensor. The procedure is identical to that for the ammonium sensor, except that the calibrant values are in mg/L of NO_3-N instead of NH_4-N.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

CHLORIDE

When selecting **ISE5-CL-**, you will be given the choice of 1-point, 2-point, or 3-point calibrations for your chloride (Cl^-) sensor. The procedure is identical to that for the ammonium sensor, except that the calibrant values are in mg/L of Cl instead of NH_4-N. IMPORTANT: We recommend that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate. Thus, the low calibration value should be 10 mg/L and the high calibration value should be 1000 mg/L Cl-. The difference is due to the fact that the effect of contamination of standards from inadvertent leakage of chloride ion from either the DO probe or the reference junction of the pH probe will be less significant at higher concentrations.

NOTE: YSI strongly recommends the use of the 3-point protocol to ensure the best possible performance from all ISE sensors (ammonium, nitrate, and chloride)

OPTIC TURBIDITY

NOTE: Before calibrating your 6026 or 6136 turbidity sensor, pay particular attention to the following cautions:

- To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StablCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6026 and 6136 by either YSI or approved vendors who are listed on the YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS ARE **NOT** APPROVED FOR THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

- For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which sensor (6026 or 6136) is being calibrated. This reflects the empirically determined fact that 6026 and 6136 sensors that have been calibrated to the same value in the primary standard formazin, will have different responses in suspensions of the AEPA-AMCO beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

- The details below are relevant to the calibration of both turbidity sensors offered by YSI – 6026 and 6136. However, to calibrate a 6136 sensor, you should have Version 2.16 or later installed in your sonde.

- If you are calibrating a 6136 turbidity sensor you MUST use either a black bottomed calibration cup or laboratory glassware with the probe guard installed for the calibration. See Section 2.6.1 above for details. Failure to carry out the calibration properly can result in inaccurate readings, particularly water of very low turbidity.

- Before proceeding with the calibration, be certain that the probe compartment of the sonde has been cleaned and is free of debris. Solid particles from this source, particularly those carried over from past deployments, will contaminate the standards during your calibration protocol and cause either calibration errors and/or inaccurate field data.

When selecting **Optic X -6026-Turbidity (or 6136-Turbidity),** there will be a choice of 1-point, 2-point, or 3-point calibrations for your turbidity sensor.

The **1-point** option is normally used to zero the turbidity probe in 0 NTU standard. Place the sonde in clear water (deionized or distilled) with no suspended solids, and input 0 NTU at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the turbidity readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Select the **2-point** option to calibrate the turbidity probe using only two calibration standards. In this case, one of the standards must be clear water (0 NTU) and the other should be in the range of known turbidity for the water to be monitored. For example, if the water to be evaluated is known to be low in turbidity, an appropriate choice of standards might be 0 and 10 NTU (6026) or 0 and 12.7 NTU (6136). However, for general purpose measurements an appropriate choice of standards is usually 0 and 100 NTU (6026) or 0 and 126 NTU (6136).

To begin the calibration, immerse the sonde in the 0 NTU standard, as instructed, and press **Enter.** It is mandatory that the 0 NTU standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second turbidity standard, input the correct turbidity value in NTU, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 1000 NTU. As for the 2-point procedure, one of the standards must be 0 NTU. Because of the linearity characteristics of the sensors, we recommend that the other two standards have turbidity values of 100 and 1000 NTU. However, the user can select any values that are deemed appropriate. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all turbidity calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration.

For further information related to setting up, calibrating and running turbidity measurements, refer to **Appendix E, Turbidity Measurements**.

OPTIC CHLOROPHYLL

When selecting **Optic X - Chlorophyll,** there will be a choice of zeroing the relative fluorescence unit parameter (**Chl RFU Zero**) or calibrating with actual chlorophyll standards (**µg/L 1-point, 2-point, or 3-point**).

If you have selected **Chl RFU** as a parameter in the **Report** menu, the sonde will report only relative values of fluorescence in the sample being measured. These values could then be converted into actual chlorophyll concentrations in µg/L by using a post-calibration procedure, after the chlorophyll content of grab-samples taken during a sampling or monitoring study has been analyzed in a laboratory. This determination can involve conducting the extractive analysis procedure described for chlorophyll in *Methods for the Examination of Water and Wastewater* or by carrying out an *in situ* measurement of chlorophyll using a commercial benchtop fluorometer.

The **Chl RFU Zero** option is used to zero the fluorescence probe in a medium that is chlorophyll-free. Place the sonde in clear water, and input 0 at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the fluorescence readings have stabilized. Press

Enter after the readings have stabilized to confirm the calibration and zero the sensor. Then, press any key to return to the **Calibrate** menu.

If you select **Chl µg/L** in the initial calibration routine, there will be a choice of 1-point, 2-point, or 3-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is chlorophyll-free. If you use this method, you will either choose to utilize the default sensitivity for chlorophyll in the sonde software or to update a previous multipoint calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the chlorophyll readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Note: For the 2-point and 3-point calibrations described below, standards of known fluorescence are required. Two general types of standards can be used: (a) phytoplankton suspensions of known chlorophyll content, and (b) dye solutions whose fluorescence can be correlated to that of chlorophyll. The user is responsible for determining the chlorophyll content of phytoplankton suspensions, either by employing the extractive analysis procedure described in *Standard Methods for the Examination of Water and Wastewater*, or by analyzing the suspension *in situ* using a laboratory fluorometer. See **Section 5.14**, **Principles of Operation** and **Appendix I, Chlorophyll Measurements** of this manual for more information about chlorophyll standards.

Select the **2-point** option to calibrate the chlorophyll probe using only two calibration standards. In this case, one of the standards must be clear water (0 µg/L) and the other should be in the range of a known chlorophyll content of the water to be monitored. For example, if the water to be evaluated is known to be low in chlorophyll, an appropriate choice of standards might be 0 and 10 µg/L. However, for general-purpose measurements an appropriate choice of standards is usually approximately 100 µg/L.

To begin the calibration, immerse the sonde in the 0 µg/L standard, as instructed, and press **Enter.** It is mandatory that the 0 µg/L standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second chlorophyll standard, input the correct value in µg/L, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 400 µg/L. As with the 2-point procedure, one of the standards must be 0 µg/L. The user can select any values for the second and third standards that are deemed appropriate. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all chlorophyll calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your chlorophyll sensor, you must either initially calibrate the sensor using a phytoplankton suspension of known chlorophyll content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for "calibration" of the sensor may not result in accurate correlation between fluorescence and actual chlorophyll readings and is designed primarily to evaluate the sensor for drift. See **Section 5.14, Principles of Operation** and **Appendix I. Chlorophyll Measurements** for more information on the proper calibration of your chlorophyll sensor.

OPTIC BGA-PC

To calibrate your 6131 Blue-Green Algae-Phycocyanin (BGA-PC) sensor, select **BGA-PC cells/mL** in the initial calibration routine. There will be a choice of 1-point or 2-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is BGA-free. If you use this method, you will either choose to utilize the default sensitivity for BGA-PC in the sonde software or to update a previous 2-point calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the BGA-PC readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the **Calibrate** menu.

Note: For the 2-point calibration described below, a standard of known fluorescence is required. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PC content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PC. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques. See **Section 5.16**, **Principles of Operation** of this manual for more information about BGA-PC standards.

Select the **2-point** option to calibrate the BGA-PC probe using two calibration standards. In this case, one of the standards must be clear water (0 µg/L) and the other should be in the range of the suspected BGA-PC content at the environmental site.

To begin the calibration, immerse the sonde in the 0 cells/mL standard, as instructed, and press **Enter.** It is mandatory that the 0 cells/mL standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second BGA-PC standard, input the correct value in cells/mL, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

For all BGA-PC calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your BGA-PC sensor, you must either initially calibrate the sensor using an algal suspension of known BGA-PC content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for "calibration" of the sensor may not result in accurate correlation between fluorescence and actual BGA-PC readings and is designed primarily to evaluate the sensor for drift. See **Section 5.16. Principles of Operation** for more information on the proper calibration of your BGA-PC sensor.

OPTIC BGA-PE

To calibrate your 6132 Blue-Green Algae-Phycoerythrin (BGA-PE) sensor, select **BGA-PE cells/mL** in the initial calibration routine. There will be a choice of 1-point or 2-point options. The 1-point selection is normally used to zero the fluorescence probe in a medium that is BGA-free. If you use this method, you will either choose to utilize the default sensitivity for BGA-PE in the sonde software or to update a previous 2-point calibration. Usually you will place the sonde in clear water, and input 0 µg/L at the screen prompt. After pressing **Enter** the screen will display real-time readings allowing you to determine when the BGA-PE readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the **Calibrate** menu.

Note: For the 2-point calibration described below, a standard of known fluorescence is required. Two general types of standards can be used: (a) phytoplankton suspensions of known BGA-PE content, and (b) dye solutions whose fluorescence can be correlated to that of BGA-PE. The user is responsible for determining the BGA-PC content of algal suspensions by using standard cell counting techniques. See **Section 5.17**, **Principles of Operation** of this manual for more information about BGA-PC standards.

Select the **2-point** option to calibrate the BGA-PE probe using two calibration standards. In this case, one of the standards must be clear water (0 cells/mL) and the other should be in the range of the suspected BGA-PC content at the environmental site.

To begin the calibration, immerse the sonde in the 0 µg/L standard, as instructed, and press **Enter.** It is mandatory that the 0 cells/mL standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second BGA-PC standard, input the correct value in cells/mL, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the **Calibrate** menu.

For all BGA-PE calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration

CAUTION: To be assured of the accuracy for field measurements made with your BGA-PE sensor, you must either initially calibrate the sensor using an algal suspension of known BGA-PE content or post calibrate your sensor in a spreadsheet by comparing the fluorescence values obtained in field studies with those obtained by laboratory analysis for chlorophyll on grab samples collected during the field study. The use of chemical dye standards for "calibration" of the sensor may not result in accurate correlation between fluorescence and actual BGA-PE readings and is designed primarily to evaluate the sensor for drift. See **Section 5.17. Principles of Operation** for more information on the proper calibration of your chlorophyll sensor.

OPTIC RHODAMINE WT

When selecting **Rhodamine,** there will be a choice of 1-point, 2-point, or 3-point calibrations for your rhodamine WT sensor.

The **1-point** option is normally used to zero the rhodamine probe in 0 ug/L standard. Place the sonde in clear water with no suspended solids, and input 0 ug/L at the screen prompt. Press **Enter** and the screen will display real-time readings that will allow you to determine when the rhodamine readings have stabilized. Press **Enter** after the readings have stabilized to confirm the calibration and zero the sensor. Then, as instructed, press any key to return to the Calibrate menu.

Select the **2-point** option to calibrate the rhodamine probe using only two calibration standards. In this case, one of the standards must be clear water (0 ug/L) and the other should be in the range of the predicted rhodamine concentration projected for the study. For general purpose measurements an appropriate choice of standards is usually 0 and 100 ug/L.

To begin the calibration, immerse the sonde in the 0 ug/L standard, as instructed, and press **Enter.** It is mandatory that the 0ug/L standard be calibrated first. The screen will display real-time readings that will allow you to determine when the readings have stabilized. Pressing **Enter** will confirm the first calibration. Following the instructions on the screen, place the sonde in the second rhodamine standard, input the correct rhodamine value in ug/L, press **Enter**, and view the stabilization of the values on the screen in real-time. After the readings have stabilized, press **Enter** to confirm the calibration. Then, as instructed, press any key to return to the Calibrate menu.

Select the **3-point** option for maximum accuracy over the entire range of 0 to 200 ug/L. As for the 2-point procedure, one of the standards must be 0 NTU. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sonde in the additional solution to complete the 3-point procedure.

For all rhodamine calibration procedures, be certain that the standard and sensor are thermally equilibrated prior to proceeding with the calibration.

REESTABILISHING DEFAULT CALIBRATION – "UNCAL" COMMAND

If, for any reason, you want to return to the factory default settings (slope and offset) for any parameter, follow the instructions below:

- Activate any calibration screen (1-point, 2-point, or 3-point) where a numerical entry is requested. In the example below, a 2-point turbidity calibration was selected.
- Instead of entering a numeric value, type the word "uncal" and press **Enter**.
- An "uncal" entry at any calibration prompt will reset both slope and offset for this parameter to the factory default settings.

```
-----Turbidity calibration--
1-1 point
2-2 point
3-3 point

Select option (0 for previous
menu): 2

Enter 1st Turbid NTU:uncal
```

NOTE: When using the 650 MDS as the sonde interface device, the "uncal" operation is performed by holding the **Enter** key down and then pressing the **Esc** key. See **Section 3** of this manual for more details.

CALIBRATION RECORD – THE GLP FILE

When any sensor is calibrated, 6-series sondes will automatically create a file in sonde memory that provides details of the calibration coefficients before and after the calibration. The file will have a .glp extension and will have the Circuit Board Serial # as the default filename. The file can be viewed by following the path File|Directory|View from the Main sonde menu.

```
-------------File details-------------
1-View file
2-File:00003001.glp
3-Samples:     39
4-Bytes:    790
```

```
------------------File-----------------
1-Directory     4-View file
2-Upload        5-Quick view file
3-Quick Upload  6-Delete all files


Select option (0 for previous menu): 1
```

```
Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6 - 00003001.glp    39
```

Pressing 1-View file will show the calibration record for the sonde. An example is shown below:

```
m/d/y hh:mm:ss      S/N                Type    Value
08/23/2001 17:07:50 00003001    Conductivity gain 1.000000
08/23/2001 17:07:50 00003001             DO gain 1.000000
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:07:50 00003001  pH gain (pH-7)*K/mV -5.05833
08/23/2001 17:07:50 00003001   pH offset (pH-7)*K 0.000000
08/23/2001 17:07:50 00003001        ORP offset mV 0.000000
08/23/2001 17:07:50 00003001         TDS constant 0.650000
08/23/2001 17:07:50 00003001          Turb Offset 0.000000
08/23/2001 17:07:50 00003001              Turb A1 500.0000
08/23/2001 17:07:50 00003001              Turb M1 500.0000
08/23/2001 17:07:50 00003001              Turb A2 1000.000
08/23/2001 17:07:50 00003001              Turb M2 1000.000
08/23/2001 17:07:50 00003001           Chl Offset 0.000000
08/23/2001 17:07:50 00003001               Chl A1 100.0000
08/23/2001 17:07:50 00003001               Chl M1 100.0000
08/23/2001 17:07:50 00003001               Chl A2 200.0000
08/23/2001 17:07:50 00003001               Chl M2 200.0000
08/23/2001 17:07:50 00003001         Fluor Offset 0.000000
08/23/2001 17:07:50 00003001              DO gain 1.103424
08/23/2001 17:07:50 00003001        DO local gain 1.000000
```

The data in the display shows a new sonde (Circuit Board # 00003001) which has just had its dissolved oxygen sensor calibrated. Note that the initial values for all parameters are the default settings. Only the last two entries (DO gain and DO local gain) have been affected by the calibration of the oxygen sensor. If the conductivity sensor is now calibrated, the new conductivity gain value is now automatically appended to the record as shown below:

```
m/d/y hh:mm:ss      S/N                Type    Value
08/23/2001 17:07:50 00003001    Conductivity gain 1.000000
08/23/2001 17:07:50 00003001             DO gain 1.000000
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:07:50 00003001  pH gain (pH-7)*K/mV -5.05833
08/23/2001 17:07:50 00003001   pH offset (pH-7)*K 0.000000
08/23/2001 17:07:50 00003001        ORP offset mV 0.000000
08/23/2001 17:07:50 00003001         TDS constant 0.650000
08/23/2001 17:07:50 00003001          Turb Offset 0.000000
08/23/2001 17:07:50 00003001              Turb A1 500.0000
08/23/2001 17:07:50 00003001              Turb M1 500.0000
08/23/2001 17:07:50 00003001              Turb A2 1000.000
08/23/2001 17:07:50 00003001              Turb M2 1000.000
08/23/2001 17:07:50 00003001           Chl Offset 0.000000
08/23/2001 17:07:50 00003001               Chl A1 100.0000
08/23/2001 17:07:50 00003001               Chl M1 100.0000
08/23/2001 17:07:50 00003001               Chl A2 200.0000
08/23/2001 17:07:50 00003001               Chl M2 200.0000
08/23/2001 17:07:50 00003001         Fluor Offset 0.000000
08/23/2001 17:07:50 00003001              DO gain 1.103424
08/23/2001 17:07:50 00003001        DO local gain 1.000000
08/23/2001 17:23:13 00003001    Conductivity gain 0.979114
```

Note that the default value of the conductivity “Value” is 1.00 in the .glp format shown above. This relative number is equivalent to a real cell constant of 5.00 which is provided in the **Advanced|Cal**

Constants and is described in Section 2.9.8. All other values in the .glp file are equivalent to those shown in the **Advanced|Cal Constants** menu.

CAUTION: Calibration records for all sensors will automatically be stored in the .glp file until the **Delete All Files** command is used from the **File** menu. However, if the Delete command is issued, all files, including the .glp (calibration record) file will be lost. Therefore, it is extremely important to remember to upload the .glp file to a PC or a 650 Display/Logger prior to deleting files from the sonde. See Section 2.9.3 for instructions on the upload and viewing of the .glp file.

2.9.3 FILE

Selections from the File menu allow the user to access data that has been stored in the sonde flash disk memory. Select **3-File** from the Main menu.

```
------------------File-----------------
1-Directory     4-View file
2-Upload        5-Quick view file
3-Quick Upload  6-Delete all files


Select option (0 for previous menu): 1
```

Select **1-Directory** to view all files currently stored in sonde flash disk memory. The screen below shows 5 files of varying sizes. To examine the details of each file, press the associated number (e.g., 4 for CLRLAKE2.dat) and an additional screen will be displayed as shown below that quantifies the time of the deployment, the sample interval, and the site where the sonde was used. In addition, the data in the file can be viewed by using the **1-View file** command

```
 Filename    Samples
1-BRIDGE1.dat      19
2-BRIDGE2.dat      27
3-UPLAKE.dat       33
4-CLRLAKE2.dat    167
5-DWNLAKE2.dat     31
6-00003001.glp      3

Select option (0 for previous menu): 4
```

```
-------------File details--------
------
1-View file
2-File:CLRLAKE2.dat
3-Samples:    167
4-Bytes:   4421
5-First:08/23/2001
6-First:08:33:40
7-Last :08/23/2001
8-Last :09:04:20
9-Interval:00:00:10
A-Site:Clear Lake
```

Select **2-Upload** to view file lists in memory (same as shown above) and then upload the data to a PC or to the YSI 650 MDS Display/Logger. The uploaded data can then be processed with YSI EcoWatch for Windows to allow data manipulation and to easily generate reports, plots, and statistics. Three formats for file transfer are available: PC6000, Comma & Quote Delimited, and ASCII text.

- **PC6000** format will transfer the data so that it will be compatible with the EcoWatch for Windows (supplied with your sonde) software package. YSI recommends data transfer in this format since it is significantly more rapid than other transfer options. If this data is required in Comma & Quote Delimited and/or ASCII formats, the user can quickly generate data in these formats using the Export function in EcoWatch for Windows.

- **Comma & Quote Delimited** format is commonly used to generate files that can be imported into spreadsheet software in your PC, where you can perform custom data analysis. A comma is still the delimiter, but the radix is corrected to a period. In most cases you should set the Page Length to 0 before using this type of upload format. See the Windows Help section in EcoWatch for information on setting the page length.

- **ASCII Text** is another alternative to transferring data directly to your computer into spreadsheet or other PC-based software.

Prior to upload, a "Time window" display appears to allow you the option to select portions of the logged data to upload. You may select **1-Proceed** to upload all data logged from the dates and times shown.

```
--------------Time window--------------
1-Proceed
2-Start date=07/17/96
3-Start time=12:00:00
4-Stop  date=07/31/96
5-Stop  time=12:00:00

Select option (0 for previous menu):
```

Select **1-Proceed.** Choose the appropriate file transfer protocol. A status box will appear in the lower right quadrant of the screen. Verification of a successful transfer is indicated when all of the requested data are transferred.

```
---------------File type---------------
1-PC6000
2-Comma & ' ' Delimited
3-ASCII Text

Select option (0 for previous menu):
```

Press **0** or **Esc** to return to the File menu.

When you select the **3–Quick Upload** option, the same operation as **2-Upload** is performed, except that only the most recent flash disk file is uploaded and it is uploaded in its entirety. You still must choose the transfer format from the three options provided.

Select **4-View File** to examine the data in any file currently stored in sonde flash disk memory. You will first view the same screen as viewed in the Directory menu. From this menu choose the file of interest,

then, using the Time window menu, choose the dates and/or times of interest. If you choose dates or times that are not within the designated start and stop times, no data will be displayed.

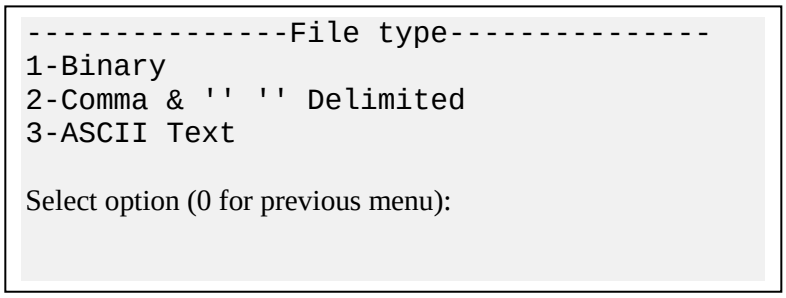
You may choose the entire file. Use the **Space Bar** to alternately stop and to resume scrolling. Use the **Esc** key to cancel the view.

Select the **5–Quick View File** option to view the last page of data from the last data file in sonde memory. This feature is particularly useful in quickly reviewing recently acquired data at field sites so that system performance can be assessed.

Select **6–Delete all files** to IRREVERSIBLY remove all files from the sonde memory (INCLUDING the .glp file that may contain valuable calibration data). It is critical not to use this option until all relevant data from sonde memory has been transferred to your computer via one of the upload options. There is a verification screen that appears, so that pressing the 6 key does not immediately delete all files at this point.

NOTE: By choosing the Delete function **only** .dat and .glp files will be erased. Calibration data for all sensors installed and calibrated on the sonde will not be deleted.

The management of the .glp calibration record file that is automatically stored in sonde memory and is described in Section 2.9.2 above is similar to that for data files. However, there are some differences in the upload procedure of which the user should be aware. When uploading a .glp file there will be a choice of three upload protocols as shown below:



The binary upload choice should ONLY be used when uploading the .glp file to a 650 Display/Logger; if the binary protocol is used in a direct upload to PC, a .glp file will indeed be transferred, but it will not be possible to open it using the current YSI software or any other text editor. Thus, during a direct transfer of the .glp file to your PC, either the CDF or ASCII formats should be used. The result will be the conversion of the file with a .glp extension in the sonde to one with a .txt extension which is now stored in the ECOWWIN\DATA subdirectory of your PC. For example, the file 00003001.glp in the sonde will become 00003001.txt on transfer to PC and the file will be in a format which can easily be viewed and edited using Notepad or other word processing software.

2.9.4 STATUS

Select **4-Status** from the Sonde Main menu to obtain general information about the sonde and its setup.

```
-----------------Status---------------
1-Version:3.01
2-Date=07/22/96
3-Time=09:04:28
4-Bat volts: 9.0
5-Bat life 21.2 days
6-Free bytes:129792
7-Logging:Inactive

Select option (0 for previous menu):
```

- **1-Version** identifies the specific version of sonde software loaded in the sonde. This number is especially useful if you are calling YSI Technical Support. It may also be useful to you if you are comparing 2 or more sondes purchased at different times.

- Select **2-Date and 3-Time** to display current date and time in 24-hour format. This is not a "live" display, but may be updated by pressing the 2 or 3 key again. This may be useful for viewing or setting real time. You may correct date or time from this submenu, by entering the corrected date or time as described in System setup. However, you cannot alter date format from this screen.

- In options **4, 5, and 6**, you can view battery voltage, battery life, and available free memory in your sonde to help you evaluate whether the current setup is appropriate to complete an active logging or to begin a study in which you have defined your logging parameters. If you press key 4, 5 or 6 before you exit this screen, it may change, since this triggers the Status screen to update information. Note that no battery information will appear for the 600R, 600QS, 600XL, 6820V2-1, and 600 OMS V2-1(nonbattery version) sondes.

- **7-Logging** provides one of two messages, active or inactive, indicating whether your sonde is in the unattended logging mode. This logging status indicator is not relevant to logging in the discrete mode, since there is no way to enter the Status screen without stopping discrete logging.

Press **0** or **Esc** to exit the Status screen and return to Main menu.

2.9.5 SYSTEM

Select **5-System** from the Sonde Main menu to set the date and time, customize the sonde communication protocol, adjust how information appears on the screen, and enter an instrument identification number and a GLP file designation.

```
1-Date & time
2-Comm setup
3-Page length=25
4-Instrument ID=YSI Sonde
5-Circuit board SN:00003001
6-GLP filename=00003001
7-SDI-12 address=0

Select option (0 for previous menu):
```

Select **Date & time.**

```
-----------Date & time setup-----------
1-(*)m/d/y          4-( )4 digit year
2-( )d/m/y          5-Date=08/11/98
3-( )y/m/d          6-Time=11:12:30

Select option (0 for previous menu):
```

Press **4** and **5** to activate the date and time functions. Pay particular attention to the date format that you have chosen when entering date. Use the 24-hour clock format for entering time. Option **4- ( ) 4 digit** year may be chosen to have the date appear with a two or four digit year.

Press **0** or **Esc** to return the System Setup menu.

Select **2-Comm setup** From the System Setup menu.

```
---------------Comm setup-------------
1-(*)Auto baud      5-( )2400 baud
2-( )300 baud       6-( )4800 baud
3-( )600 baud       7-(*)9600 baud
4-( )1200 baud

Select option (0 for previous menu): 0
```

The default is 9600, but you may change it to match your host communication interface protocol by typing in the corresponding number, 1 through 7. An asterisk confirms the selection. Auto baud may be selected along with any of the choices. The Auto baud option allows the sonde to recognize and adjust to the received characters and we recommend that it is activated.

NOTE: If you change the baud rate, exit the sonde interaction and immediately change the baud rate in EcoWatch for Windows, Comm Settings. If you do not adjust the baud rate in the PC software, the sonde will not be able to communicate with the computer or any display/logger and your system will appear to be "locked-up."

Select **3-Page length** from the System Setup menu and press **Enter**. This will allow you to control how many lines of data are sent to your display before a new header is shown. The smaller the page number, the fewer the lines of data will be transmitted to your display between headers. However, if you set the page length to zero (0), only the initial header will be displayed. In many cases, a page length of zero is the preferred configuration if you choose to upload your data in an ASCII or CDF format. See **Section 2.9.3, File Menu,** for more details.

NOTE: The header itself takes 4 lines. Therefore, if the page length is set to 25, there will be 21 lines of data and one header. Any page length less than 5 will result in no header being transmitted.

Select **4-Instrument ID** from the System setup menu to record the instrument ID number (usually the instrument serial number), and press **Enter**. A prompt will appear which will allow you to type in the serial number of your sonde. This will make sure that any data that is collected is associated with a particular sonde.

The **5-Circuit Board SN** entry shows the serial number of the PCB that is resident in your sonde (not the entire system as for Instrument ID). Unlike the **Instrument ID**, the user cannot change the **Circuit Board SN**.

Select **6-GLP filename** to enter a name for the file that is automatically generated and appended as you calibrate any of the sonde sensors. The default designation for the GLP file is the Circuit Board SN and this name can be retained if you wish. See section 2.9.3 for general information on the GLP file.

Select **7-SDI-12 address** from the System Setup menu to change the value. Input a number between 0 and 9 and then press **Enter** to confirm the selection. The SDI-12 default address is zero (0). This feature is fully described in **Section 7, Communication** and only utilized if the unit is to operate in a SDI-12 communication protocol network.

2.9.6 REPORT

The Report menu allows you to configure all reports displayed by the sonde software. You will be able to select which parameters and units of measure that are displayed during operation.

Select **6-Report** from the sonde Main menu. The following menu, or a similar menu, will be displayed. The parameters listed depend on both the sensors available and enabled on your sonde. Therefore your screen may not be identical to that shown below.

Select **Report** from the Main sonde menu to setup the report section. The Report Setup menu will be displayed.

```
-------------Report setup--------------
1-(*)Date           C-( )DOchrg
2-(*)Time hh:mm:ss  D-( )pH
3-(*)Temp C         E-( )pH mV
4-(*)SpCond uS/cm   F-(*)Orp mV
5-( )Cond           G-( )PAR1
6-( )Resist         H-( )PAR2
7-( )TDS            I-(*)Turbid+ NTU
8-( )Sal ppt        J-(*)Chl ug/L
9-(*)DOsat %        K-( )Chl RFU
A-(*)DOsat %Local   L-(*)Battery volts
B-( )DO mg/L

Select option (0 for previous menu):
```

The asterisks (*) that follow the numbers or letters indicate that the parameter will appear on all outputs and reports. To turn a parameter on or off type the number or letter, that corresponds to the parameter, after **Select option**. See **Appendix J** for instructions on activation of the parameter "DOsat %Local" and ODOsat %Local". The parameters "PAR1" and "PAR2" are associated with a special sonde equipped with a sensor for Photosynthetically Active Radiation (PAR) which can be purchased from the YSI Massachusetts. See **Section 9** of this manual for contact information and **Appendix K** for a brief description of the PAR system for potential users.

Note that the units of turbidity are automatically presented as "turbid NTU" if a 6026 sensor has been selected and "turbid+ NTU" if a 6136 sensor has been selected. The different designations are designed to differentiate the data from the two sensors types in later analysis.

For parameters with multiple unit options such as temperature, conductivity, specific conductance, resistivity and TDS, a submenu will appear as shown below, allowing selection of desired units for this parameter.

```
--------------Select units-------------
1-(*)NONE
2-( )Temp C
3-( )Temp F
4-( )Temp K

Select option (0 for previous menu): 2
```

After configuring your display with the desired parameters, press **Esc or 0** to return to the Main menu.

Even if all of the sensors are enabled, the measurements for those sensors will not appear on your display unless the parameter is selected in Report setup. In order for a specific parameter to show up on a report:

- The sensor must first be enabled (turned on).
- That parameter must be activated in the Report setup.

In the above example, if the appropriate sensors have been activated in the Sensor setup section, the following parameters will be displayed to the computer screen or captured to a computer or data collection platform when the sonde is sampling: Temperature in C, Specific Conductance in uS/cm, Dissolved

Oxygen in % air saturation, Dissolved Oxygen in mg/L, pH, ORP in millivolts, Turbidity in NTUs and Chlorophyll in ug/L. Date and time will also be displayed.

NOTE: Do not attempt to memorize or associate a number or letter with a particular parameter. The numbering scheme is dynamic and changes depending on the sensors which have been enabled.

The following list is a complete listing of the abbreviations utilized for the various parameters and units available in the Report setup menu.

Parameter	Description
Date	Day/Month/Year (format selectable)
Time	Hour:Minute:Second (24-hour clock format)
Temp C	Temperature in degrees Celsius
Temp F	Temperature in degrees Fahrenheit
Temp K	Temperature in degrees Kelvin
SpCond mS/cm	Specific Conductance in milliSiemens per centimeter
SpCond uS/cm	Specific Conductance in microSiemens per centimeter
Cond mS/cm	Conductivity in milliSiemens per centimeter
Cond uS/cm	Conductivity in microSiemens per centimeter
Resist MOhm*cm	Resistivity in MegaOhms * centimeter
Resist Kohm*cm	Resistivity in KiloOhms * centimeter
Resist Ohm*cm	Resistivity in Ohms * centimeter
TDS g/L	Total dissolved solids in grams per liter
TDS kg/L	Total dissolved solids in kilograms per liter
Sal ppt	Salinity in parts per thousand (set to local barometer at calibration)
DOsat %	Dissolved oxygen in % air saturation from Rapid Pulse Sensor
DOsat % Local	Dissolved oxygen in % air saturation (set to 100 % at calibration) from the Rapid Pulse sensor
DO mg/L	Dissolved oxygen in milligrams per liter from Rapid Pulse Sensor
DO chrg	Dissolved oxygen sensor charge from Rapid Pulse Sensor
ODOsat %	Dissolved oxygen in % air saturation from ROX Optical Sensor
ODOsat % Local	Dissolved oxygen in % air saturation (set to 100 % at calibration) from the ROX Optical Sensor
ODO mg/L	Dissolved oxygen in mg/L from ROX Optical Sensor
Press psia	Pressure in pounds per square inch absolute
Press psir	Pressure in pounds per square inch relative
Depth meters	Water column in meters
Depth feet	Water column in feet
pH	pH in standard units
pH mV	millivolts associated with the pH reading
Orp mV	Oxidation reduction potential value in millivolts
NH4+ N mg/L	Ammonium Nitrogen in milligrams/liter
NH4+ N mV	Ammonium Nitrogen in millivolt reading
NH3 N mg/L	Ammonia Nitrogen in milligrams/liter
NO3- N mg/L	Nitrate Nitrogen in milligrams/liter
NO3- N mV	Nitrate Nitrogen in millivolt reading
Cl- mg/L	Chloride in milligrams/liter
Cl- mV	Chloride in millivolt reading
Turbid NTU	Turbidity in nephelometric turbidity units from 6026 sensor
Turbid+ NTU	Turbidity in nephelometric turbidity units from 6136 sensor
Chl ug/L	Chlorophyll in micrograms/liter
Chl RFU	Relative fluorescence units for the chlorophyll sensor
BGA-PC cells/mL	Phycocyanin-Containing Blue-green Algae content in cells/mL
BGA-PC RFU	Relative fluorescence units for the BGA-PC sensor
BGA-PE cells/mL	Phycoerythrin-Containing Blue-green Algae content in cells/mL
BGA-PE RFU	Relative fluorescence units for the BGA-PE sensor

Rhod ug/L	Rhodamine WT in micrograms/liter
PAR1	Output from special photosynthetically active radiation sensor in mv or Photon Flux Density in umoles/sec/m2
PAR 2	Output from special photosynthetically active radiation sensor in mv or Photon Flux Density in umoles/sec/m2

2.9.7 SENSOR

The **Sensor** menu allows you to Enable or Disable (turn on or off) any available sensor and, in some cases, to select the port in which your sensor is installed.

From the Sonde Main menu select **7-Sensor** and the following display will appear.

```
------------Sensors enabled------------
1-(*)Time           7-( )ISE3 NONE
2-(*)Temperature    8-( )ISE4 NONE
3-(*)Conductivity   9-( )ISE5 NONE
4-(*)Dissolved Oxy  A-( )Optic T
5-(*)ISE1 pH        B-( )Optic C
6-(*)ISE2 Orp       C-(*)Battery

Select option (0 for previous menu):
```

Note that the exact appearance of this menu will vary depending upon the sensors available on your sonde.

When a particular sensor is active, an asterisk will appear in the parentheses associated with the selection. In this example the time, temperature, conductivity, dissolved oxygen, pH, ORP, and battery sensors are enabled. To disable a sensor, simply press the number of the active sensor or port, and the asterisk will disappear.

For the ISE and Optic selections, press the appropriate number, and then enable or disable the sensor using the submenu choices. Be certain that the appropriate sensor is “enabled” in the submenu according to the sonde bulkhead port in which it is physically installed. For example, if an ammonium sensor is placed in the port labeled “3” on the bulkhead, enable the sensor as ISE3 in the menu structure.

The following screen is the submenu selection structure for ISE3, ISE4 and ISE5.

```
--------------Select type--------------
1-( )ISE3 NH4+
2-( )ISE3 NO3-
3-( )ISE3 Cl-
4-( )ISE3 PAR1

Select option (0 for previous menu):
```

As noted above, the ISE3 PAR1 selection is used in a special instrument mated to a sensor for Photosynthetically Active Radiation that is available from Endeco/YSI. See **Section 9** for contact information and **Appendix K** for a brief description of the PAR system for potential users.

A submenu similar to that below will appear if any of the Optic options (T, C, B, or O) is chosen as a port for a particular optical sensor..

```
--------------Select type--------------
1-(*)Optic-T(or C,B,O) Turbidity-6026
2-( )Optic-T(or C,B,O) Turbidity-6136
2-( )Optic-T(or C,B,O) Chlorophyll
3-( )Optic-T(or C,B,O) Rhodamine

Select option (0 for previous menu):
```

Any available optical probe can be installed in any optical port on YSI 6-series sondes. If a single port is present (600 OMS V2-1, 6820V2-1, 6920V2-1), then the port will be designated "Optic T" in the software even though the port is not physically labeled with a "T" on the bulkhead. The two optical ports in the 6600V2-2, 6600EDS V2-2, 6820V2-1. and 6920V2-2 are labeled "Optic T" and "Optic C", both in the software and on the bulkhead. Selection of either "Optic T" or "Optic C" in the software will produce submenus that allow the proper optical sensor to be selected. The four optical ports in the 6600V2-4 are labeled "Optic T", "Optic C", "Optic B", and "Optic O", both in the software and on the bulkhead. Selection of any of the options in the software will produce submenus that allow the proper optical sensor to be selected. Note, however, that only one probe of any type can be installed and activated in sondes with multiple optical ports. For example, it is not possible to use chlorophyll probes in both Optic T and Optic C ports of the 6600V2-2.

NOTE CAREFULLY: It is NOT possible to simultaneously activate BOTH the 6562 Rapid Pulse polarographic dissolved oxygen sensor and the 6150 ROX Optical dissolved oxygen sensor. Activation of either sensor will automatically deactivate the other selection. Thus, users of 6600V2-2, 6600EDS V2-2, 6820V2-1, and 6920V2-1 sondes CANNOT measure oxygen with both types of sensors.

NOTE: If you are using a previously purchased 6036 turbidity probe (discontinued on 1/1/02) with your sonde, select the "(*) Turbidity-6026" option in the above menu.

2.9.8 ADVANCED

From the Sonde Main menu select **8-Advanced** to display the sensor calibration constants, additional setup options, sensor coefficients and constants, and digital filtering options. The parameters listed depend on both the sensors installed and the sensors enabled, therefore your screen may not be identical to those shown below.

```
----------------Advanced-------------
1-Cal constants
2-Setup
3-Sensor
4-Data filter

Select option (0 for previous menu): 1
```

Select **1-Cal constants** to display the calibration constants, as shown in the following example. Note that values only appear for the enabled sensors.

```
------------Cal constants------------
1-Cond:5              B-NO3 A:2.543
2-DO gain:1.3048      C-Cl J:99.5
3-mV offset:0         D-Cl S:-0.195
4-pH offset:0         E-Cl A:2.543
5-pH gain:-5.05833    F-Turb Offset:0
6-NH4 J:51.2          G-Turb A1:500
7-NH4 S:0.195         H-Turb M1:500
8-NH4 A:1.092         I-Turb A2:1000
9-NO3 J:99.5          J-Turb M2:1000
A-NO3 S:-0.195

Select option (0 for previous menu): 0
```

The following table provides the default value, operating range, and comments relative to the calibration constants. Error messages will appear during calibration if values are outside the indicated operating range unless the designation is "not checked".

Parameter	***Default***	***Operating range***	***Comments***
Cond:	5	4 to 6	Traditional cell constant
DO gain:	1	0.5 to 2.0	
ODO gain	1	0.75 to 1.40	
ODO Tzero	Same as K1	+/- 0.45 from K1	ODO value at zero oxygen after 2-point cal
ODO K1	N/A	N/A	ODO value at zero oxygen
ODO K2	N/A	N/A	ODO regression coefficient
ODO K3	N/A	N/A	ODO regression coefficient
ODO K4	N/A	N/A	ODO regression coefficient
Pres offset:			
if not vented	-14.7	-20.7 to -8.7	
if vented	0.0	-6 to 6	
mV offset:	0.0	-100 to 100	
pH offset:	0.0	-400 to 400	
pH gain:	-5.0583	-6.07 to -4.22	
NH4 J	51.2	Not checked	
NH4 S	0.195	0.15 to 0.217	
NH4 A	1.092	Not checked	
NO3 J	99.5	Not checked	
NO3 S	-0.195	-0.217 to -0.15	
NO3 A	2.543	Not checked	
Cl J	99.5	Not checked	
Cl S	-0.195	-0.217 to -0.15	
Cl A	2.543	Not checked	
Turb Offset	0	-10 to 10	
Turb A1	500	0.6 to 1.5	Range is ratio of M1 to A1
Turb M1	500		
Turb A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Turb M2	1000		
Turb+ Offset	0	-10 to 20	
Turb+ A1	500	0.6 to 1.5	Range is ratio of M1 to A1

Turb+ M1	500		
Turb+ A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Turb+ M2			
Chl Offset	0	-30 to 20	
Chl A1	500	0.6 to 1.5	Range is ratio of M1 to A1
Chl M1	500		
Chl A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Chl M2	1000		
Chl RFU Offset	0	-0.1 to +0.1	
PC Offset	0	-5000 to 10000	
PC Gain	1	Not checked	
PC RFU Offset	0	Not checked	
PE Offset	0	-5000 to 15000	
PE Gain	1	Not checked	
PE RFU Offset	0	Not checked	
Rhod Offset	0	-10 to 10	
Rhod A1	500	0.6 to 1.5	Range ratio of M1 to A1
Rhod M1	500		
Rhod A2	1000	0.6 to 1.5	Range is ratio of (M2-M1) to (A2-A1)
Rhod M2	1000		

To reset a calibration cell constant, access the sonde Calibrate menu. Then select the sensor and type "UNCAL" instead of the value. This action will change the calibration constants of that sensor back to the factory default.

From the Advanced menu, select **2-Setup** to display miscellaneous options. Type the appropriate number to activate/deactivate any of the displayed features.

```
------------Advanced setup--------
1-(*)VT100 emulation
2-Start up:Normal
3-( )Comma radix
4-( )Auto sleep RS232
5-( )Auto sleep SDI12
6-( )Multi SDI12
7-( )Full SDI12
8-( )Sample and hold
```

1-(*)VT100 emulation. Activate this option for VT100 terminal emulation. This feature allows the sonde to send escape sequences to clear the screen which in turn results in an improved display. Usually this feature should be activated, but, if your terminal or terminal emulator shows odd characters at the beginning of each menu title, then turn this item off. With the feature off, the sonde will send several carriage returns and line feeds to 'clear' the display. The number of <cr>'s and <lf>'s is determined by the page length setting.

2- Start up. This option allows the user to select the mode of sonde operation when power is applied or a "reset" command is issued. After pressing the "2" key, the following options will be displayed.

```
------Start up:---------------
1-(*)Normal
2-( )Menu
3-( )Run
4-( )Menu Run
5-( )NMEA

Select option (0 for previous
menu):
```

Users should select the option for their application based on the descriptions below. Note, however, that the "Start up Normal" selection will be best for most applications.

1- ( ) Start up Normal. This selection is the factory default and should be used for most operations of the sonde. When power is applied or a "reset" command is issued, the sonde firmware will return the "#" prompt. The user should then type "menu" to access the sonde firmware functionality

2- ( ) Start up Menu. When this item is enabled, the sonde will go directly to menu mode when power is applied to the sonde. If the command line mode is not useful for your applications, then enabling this item will negate the need to type "Menu" and **Enter** at the # prompt to access the Main sonde menu. Activation of this item is NOT recommended except for special applications.

3-( ) Start up Run. When this item is enabled the sonde will start sampling and output data as soon as power is applied to the sonde. If you are using your sonde for Unattended sampling, do not activate this mode. Activation of this item is NOT recommended except for special applications.

4-( ) Start up Menu Run. When this item is enabled, the sonde will first enter the menu mode and then the run mode where it will start sampling. If you are using your sonde for Unattended sampling, do not activate this mode. Activation of this item is NOT recommended except for special applications.

5-( ) Start up NMEA. When this item is active, the sonde will start sampling and output data in a format which is compatible with devices which utilize the NMEA protocol. See **Appendix N - NMEA Applications** for additional details. Activation of this item is NOT recommended except for special applications.

3-( )Comma radix. When this item is enabled, the sonde will replace decimal points with commas when printing numbers. NOTE: Regardless of this setting, SDI-12 'D' commands will still respond using a decimal point.

4-(*)Auto sleep RS232. Activation of this feature enables a power savings system when communicating with the sonde in RS-232 mode. When enabled, power is only applied to the sensors during sampling or calibration. The most important aspect of this feature is its effect on the dissolved oxygen protocol as described in Section 2.9.2. For this reason, this feature should be activated for long term monitoring studies in the RS-232 communication mode and deactivated for sampling studies where the user is present and the sonde runs continuously. Even with Autosleep inactive, the sonde will "sleep" after one minute with no communications.

5-(*)Auto sleep SDI12. Activation of this feature enables the power savings system when communicating with the sonde in SDI-12 mode. This is basically the same as item 5 above except that it is used in

communication via the SDI-12 interface. Also, the sonde will "sleep" in about 100 milliseconds in the absence of communication, rather that waiting one minute in the Auto sleep RS-232 mode.

6-( ) Multi SDI12. Modifies the SDI12 protocol as follows: (1) No SDI12 service request will be issued. (2) Break commands will not cause a measurement reading to be aborted. Normally, you should leave this feature "off".

7-( ) Full SDI12. Enabling this feature forces full SDI-12 specification in order to pass the NR Systems SDI-12 Verifier. Disabling this feature will allow the unit to be more fault tolerant and will save some power. We recommend that you leave this feature "off".

8-( ) Sample and Hold. This feature is designed to be activated ONLY for studies in which your sonde is attached to a YSI 6500 Process Monitor. When "Sample and Hold" is active, the 6500 display and the SCADA output of the 6500 becomes equivalent to the internal memory of the sonde while an Unattended study is running. In the Unattended mode, the sonde "sleeps" between periodic samples with the interval between samples defined by the user. This method of operation results the extension of both the sonde battery life (not important in 6500 applications) and the time between required sensor maintenance procedures (which is important to 6500 applications using Rapid Pulse DO). After activation of the feature another entry will appear automatically which will allow you to input your sample interval which defines how often data is transmitted to the 6500 display. This new sample interval will automatically become the sample interval for the **Run|Discrete sample** mode of operation and you will not be able to change the interval until **Sample and Hold** is deactivated. In addition, the interval in the Run|Unattended **sample** mode will also change to the Sample and Hold interval. In this case, however, you will be able to change the Unattended Sample interval, but with the caveat that the **Sample and Hold interval** will also change, i.e., the **Unattended sample interval** and the Sample and Hold interval MUST be synchronized and the software assures that this will be the case.

For DCP applications, when "Sample and Hold" is active, the routine which triggers optical wipers, the sensor warm-up pattern, and the acquisition of data will be controlled by the sonde rather than the DCP. If the Unattended mode of the sonde is inactive, the data will be stored in a memory buffer and then acquired by the DCP when the "D" command is issued. If the Unattended mode is active, then the data will be stored both in the memory buffer and sonde memory for acquisition by the DCP. Use of the "Sample and Hold" feature with a DCP is particularly useful if you are also logging a back-up file to internal sonde memory. In this case, the wiping and data acquisition sequence of the sonde will ONLY be triggered by the sonde itself rather than by BOTH the sonde and the DCP and this will result in significantly less power consumption from the DCP battery and/or power system.

NOTE CAREFULLY: When **Sample and Hold** is active, the sonde will behave as if it is in an **Unattended sample** mode EVEN IF AN UNATTENDED SAMPLE HAS NOT BEEN ACTIVATED. Therefore, to conserve batteries, you should always DEACTIVATE the **Sample and Hold** feature when your sonde is not attached to the 6500 Process Monitor.

Select **3-Sensor** to display and change user-configurable constants as shown in the following display. Type the appropriate number to change to these parameters. Note that the listed items depend on which sensors your have active in your sonde setup.

```
------------Advanced sensor----------
1-TDS constant=0.65
2-Latitude=40
3-Altitude Ft=0
4-(*)Fixed probe
5-( )Moving probe
6-DO temp co %/C=1.1
7-DO warm up sec=40
8-(*)Wait for DO
9-Wipes=1
A-Wipe int=1
B-SDI12-M/wipe=1
C-Turb temp co %/C=0.3
D-(*)Turb spike filter
E-Chl temp co %/C=0


Select option (0 for previous menu):
```

NOTE: The number of items on this menu depends greatly on the sensors that are available and enabled on your sonde. Below we describe every possible item on this menu. Your sonde probably may not have every item described below.

To edit one of the following menu items choose the number or letter that corresponds to it.

TDS constant=0.65 This selection allows you to set the constant used to calculate TDS. TDS in g/L is calculated by multiplying this constant times the specific conductance in mS/cm. This item will only appear if the conductivity sensor is enabled in the "Sensors enabled" menu. See **Section 53, Principles of Operation** for more information on the TDS parameter.

Salinity=0 This selection allows you to input a manually-acquired value of salinity for calculating other parameters such as DO mg/L and depth. *This item is not used or displayed if the conductivity sensor is enabled in the Sensors menu.*

Pres=0 psi This selection allows you to set a value of pressure for calculating other parameters like salinity. *This item is not used or displayed if the pressure sensor is enabled in the Sensors menu.*

Latitude=40 This selection allows you to input the global position (latitude) where the sonde is sampling. The units are degrees. For accuracy, enter the decimal equivalent to indicate degrees and minutes. For example, enter 41° 30 ' as 41.5. This value is used in the calculation of depth or level to account for global variations in the gravitational field. *This item will only appear if the pressure sensor is enabled in the Sensors menu.*

Flow Setup… This selection allows you to setup the sonde to output flow information. See **Appendix F, Flow** for detailed information on how to setup the Flow parameter. *This item will only appear if the sonde has shallow vented level.*

Altitude=0 This selection allows you to input the local altitude (relative to sea level) where the sonde is sampling. The units are feet. You may enter positive or negative values (range is -276 to 29028) to represent altitudes above or below sea level. This value is used in the

calculation of depth or level. *This item will only appear if the pressure sensor is enabled in the Sensors menu.*

(*)Fixed probe This selection allows you to identify how your sonde is being used. If your sonde is "fixed" or secured to a dock, buoy, platform or similar, select this option. This information is used in the calculation of depth and level. *This item will only appear if the Pressure-Abs sensor is enabled in the Sensors menu.*

(*)Moving probe This selection allows you to identify how your sonde is being used. If your sonde is being used in depth profiling select this option. This information is used in the calculation of depth and level. *This item will only appear if the Pressure-Abs sensor is enabled in the Sensors menu.*

DO temp co=1.1%/C This selection allows you to input the Rapid Pulse dissolved oxygen temperature coefficient. Do not change this value unless you consult YSI Technical Support. *This item will only appear if a Rapid Pulse DO sensor is enabled in the Sensors menu.*

.

ODO temp co=1.50%/C This selection allows you to input the ROX Optical dissolved oxygen temperature coefficient. Do not change this value unless you consult YSI Technical Support. *This item will only appear if a ROX Optical DO sensor is enabled in the Sensors menu.*

DO warm up=40 This selection allows you to set the amount of time allowed for the Rapid Pulse DO sensor warm up in seconds. Normally the default value of 40 seconds is adequate for most applications. However, there may be certain situations in which greater DO accuracy can be attained by increasing this time. Consult YSI Technical Support if you feel that your DO warm up time is incorrect. *This item will only appear if the Rapid Pulse Polarographic DO sensor is enabled in the Sensors menu.*

(*)Wait for DO When this feature is enabled, the sonde is forced to wait for the Rapid Pulse DO warm up time to expire before displaying any readings. Note that in SDI12 mode or while calibrating the Rapid Pulse DO sensor, the warm up time is used regardless of the activation of this item. Disabling this item allows you to see data without having to wait during the Rapid Pulse DO warm up time. Under normal operating conditions, this item should be turned off. If you are using the sonde with a data logger in RS232 mode and will be turning the sonde "on" and "off" for each sample, then you may want to enable this item so that only stable DO data are recorded. *This item will only appear if the Rapid Pulse Polarographic DO sensor is enabled in the Sensors menu.*

Wipes=1 If any number of optical sensors are enabled, this selection will determine the number of cleaning cycles which will occur when the wiper is activated manually or automatically. Since the wiper functions bidirectionally, a selection of "1" results in two passes of the wiper over the optical face. In most applications, a single cleaning cycle is adequate to keep the optical surface free of bubbles and fouling. However, in particularly harsh environments additional cleaning cycles may be needed and can be selected here. *This item will only appear if a optical sensor is enabled in the Sensors menu.*

Wipe Int=1 In applications where an optical probe is installed in the sonde and the instrument is collecting data in the SDI-12 communication mode, the wiper mechanism of the probe should be activated automatically in a periodic manner to clean the optical surface for fouling and bubbles. The value entered at this selection is the number of minutes between each automatic cleaning cycle. Thus, if Wipe Int is set to "5" and the instrument is in the Run mode, the wiper will activate every 5 minutes with no manual input. *This item will only appear if an optical sensor is enabled in the Sensors menu.*

The value of Wipe Int is sometimes overridden when the instrument is set up in the Unattended sampling mode. Under these conditions, the wiper will be automatically activated at the interval assigned in the Unattended setup rather than that assigned in Wipe Int. Thus, in an Unattended study setup at a 15 minute sampling interval, the wiper will be activated only once every 15 minutes rather than at the indicated Wipe Int of 1 minute.

CAUTION: If Wipe Int is set to zero, then no wiping will occur either in Discrete or Unattended Sampling. Make certain that Wipe Int is set to some finite value prior to setting up an Unattended study or no automatic cleaning will occur.

SDI12-M/Wipe=1 This is the number of wiping cycles when the sonde is in SDI12 mode. The wiper for the 6026 and 6136 turbidity, 6025 chlorophyll, and 6130 rhodamine WT sensors will automatically wipe each time this many SDI12 "M" commands have been issued. If this value is set to zero, then no automatic wiping will occur. *This item will only appear if a turbidity, chlorophyll, or rhodamine WT sensor is enabled in the Sensors menu.*

Turb temp co %/C=0.3 This entry sets the coefficient for the temperature compensation of turbidity readings from the 6026 and 6136 sensors. The default values of 0.3 (6026) and 0.6 (6136) should not be changed by the user without consulting YSI Technical Support. *This item will only appear if a turbidity sensor is enabled in the Sensor menu.*

(*) Turb Spike Filter When this item is activated, the output of the turbidity sensor is mathematically processed to minimize the effect of unusual (or "bad") readings on the overall data presentation. In most cases, these "spike" events are the result of the chance passage of large suspended particles across the probe optics just at the time a reading is taken. Activation of this option generally results in a better display of the "average" turbidity of the water under examination and its use is recommended for most sampling and unattended applications. *This item will only appear if a turbidity sensor is enabled in the Sensors menu.*

Chl temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of chlorophyll readings from the 6025 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. See Section 5.12, Chlorophyll and **Appendix I, Chlorophyll Measurements** of this manual for more information. *This item will only appear if a chlorophyll sensor is enabled in the Sensors menu.*

BGA-PC temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of BGA-PC readings from the 6131 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. **See Section 5.16, Principles of Operation** of this manual for more information. *This item will only appear if a BGA-PC sensor is enabled in the Sensors menu.*

BGA-PE temp co %/C=0.0 This entry sets the coefficient for the temperature compensation of BGA-PE readings from the 6132 sensor. The default value of zero should only be changed by the user after establishing the temperature compensation factor for the phytoplankton sample in question. See **Section 5.17, Principles of Operation** of this manual for more information. *This item will only appear if a BGA-PE sensor is enabled in the Sensors menu.*

From the Advanced menu, select **4-Data filter** to display data smoothing options. Type the appropriate number to activate/deactivate any of the displayed features.

Sondes with **no optical (turbidity, chlorophyll, or rhodamine WT) probes** enabled will display the following menu.

```
------------Data filter setup----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant=4
4-Threshold=0.001

Select option (0 for previous menu):
```

If any optical probe is enabled in the **Sensor** menu, then the menu will appear as follows.

```
------------Data filter setup----------
1-(*)Enabled
2-( )Wait for filter
3-Time constant. . .
4-Threshold. . .

Select option (0 for previous menu):
```

Choosing **3-Time Constant** will display the following the following or a similar menu to reflect your optical probe selection:

```
------------Time constant ----------
1- Turbid=12
2- Chl=12
3- Other=4


Select option (0 for previous menu):
```

Recommended settings for time constants are turbidity 12, rhodamine WT 12, chlorophyll 12, BGA-PC 24, BGA-PE 24, ODO 12, and “other” 4. Note that the time constant can be set independently for each optical probe and that time constant choices are only available for activated sensors. Rhodamine WT would appear in the display below if it had been activated as a sensor. All “other” sensors use the same time constant as shown below.

Choosing **4-Threshold** will display the following:

```
---------------Threshold-------------
1-Turbid=0.01
2-Chl=1
3-Other=0.001

Select option (0 for previous menu):
```

Setting thresholds is done in the same manner. Recommended threshold settings are 0.01 for turbidity, 1.0 for chlorophyll, 1.0 for rhodamine WT, 1.0 for BGA-PC, 1.0 for BGA-PC and 0.001 for "other".

The following descriptions provide additional information about the **Data Filter** feature.

1-(*) Enabled. Activating this item will result in data filtering according to the values set in (2), (3), and (4).

2-(*) Wait for filter. If this feature is activated, readings will be available for output only after the unit has warmed up for a time period equal to the Time Constant plus an extra 4 seconds. This feature is useful, for example, if you are operating in SDI12 mode and want to average the data over a particular period of time. In such a case, you would not want the filter to be engaging and disengaging, so the value of the Threshold should be set to a large value like 1. This feature should not be activated for normal use of the sonde.

3-Time Constant. This value is the time constant in seconds for the software data filter. Increasing the time constant will result in greater filtering of the data, but will also slow down the apparent response of the sensors.

4-Threshold. This value determines when the software data filter will engage/disengage. When the difference between two consecutive unfiltered readings is larger than the threshold, then the reading is displayed unfiltered. When the difference between two consecutive readings drops below the threshold, readings will be filtered again. For the purposes of the filter, consecutive readings are never more than 0.5 seconds apart. When sampling faster than 0.5 seconds consecutive readings will be at the faster rate and you may want to adjust the threshold accordingly. See section 2.9.1 for details on fast sampling.

The threshold feature is intended to speed response to large changes in a reading. For example, when changing from pH 7 buffer to a pH 4 buffer in a calibration, it is likely that the filter will disengage for a time showing unfiltered readings until the sensor has nearly equilibrated with the new buffer. At that time, the filter will re-engage and show filtered readings. Without disengaging the filter for awhile, much more time would be required to come to equilibrium after large changes in reading.

During the first time constant after the filter first engages, the output reflects a simple average of all the readings from the time the filter engaged until the present. Once the filter has been engaged for the period of the time constant, it becomes a simple filter with a time constant equal to that set in **3-Time Constant**. Each time the filter disengages and then re-engages, this process is repeated.

Filter engagement and disengagement occurs for each sensor independently. One parameter may be filtered while another is not because readings from one sensor are changing more than another.

Example: Moving a sonde from the air to a river water sample. Assume that the temperature of the sonde is similar to the temperature of the water, and that the water is in equilibrium with the air. The temperature and oxygen readings taken in the water will be very similar to those taken in the air. The conductivity reading in air is near zero, and quite likely, is a very different reading in the water. The filter for the

conductivity readings will likely disengage when the sonde is first placed in the river water, but stay engaged for the temperature and dissolved oxygen readings.

The filters for turbidity, chlorophyll, and rhodamine WT are somewhat different. For these sensors, the filter is temporarily disengaged during mechanical wiping so that when wiping is finished, the reading is the most current. The filter then reengages if possible. Optical sensor readings are frozen to the output during wiping so that "bad" values are not output.

A value of 0.001 for the threshold roughly corresponds to the following changes in sensor readings:

Temp: 0.1 °C
Conductivity in the 100 mS/cm range: 0.1 ms/cm
Conductivity in the 10 mS/cm range: 0.01 ms/cm
Conductivity in the 1 mS/cm range: 0.001 ms/cm
Conductivity in the 100 µS/cm range: 0.1 us/cm
Dissolved Oxygen: 0.2 percent air saturation
pH, ORP, Ammonium, Nitrate and Chloride: 0.6 mV

A value of 0.01 for the threshold roughly corresponds to a 10NTU change in turbidity. A value of 1.0 for the chlorophyll and rhodamine WT sensors threshold effectively means that the filter will be engaged under all conditions.

2.10 CARE, MAINTENANCE AND STORAGE

This section describes the proper procedure for storage of the sensors that will maximize their lifetime and minimize the time required to get the sonde ready for a new application. This section will describe interim or short-term storage between applications where the sonde is being used at a regular interval (daily, weekly, biweekly, etc.). and long term storage, (e.g., over-the-winter), where the sonde will not be used on a regular basis for several months.

In the descriptions and instructions below, it is assumed that the user has retained the vessels (bottles, boots, etc.) in which the individual sensors were stored on initial delivery. If these specific items have been misplaced or lost, they can be replaced by contacting YSI Technical Support. Alternatively, the user may have similar (and equally acceptable) storage equipment on hand even though it was not part of the original YSI package. Common sense should be the guide on substitution of storage vessels.

REMEMBER: DO NOT ATTEMPT TO GAIN ACCESS TO THE INTERNAL CIRCUITRY OF THE SONDE.

2.10.1 SONDE CARE AND MAINTENANCE

The YSI 6570 Maintenance Kit is available for use with your sonde. The kit includes several items that will be helpful or necessary to perform the proper routine maintenance on your sonde.

The 6570 Maintenance Kit includes two types of O-rings (for probes and cable connector), probe/installation/replacement tools, two cleaning brushes for the conductivity sensor, O-ring lubricant, and a syringe for cleaning the depth sensor port.

The 6570 Maintenance Kit can be ordered from any authorized YSI dealer, or directly from YSI. See **Appendix C** for details.

When caring for your sonde, remember that the sonde is sealed at the factory, and there is never a need to gain access to the interior circuitry of the sonde. In fact if you attempt to disassemble the sonde, you would void the manufacturer's warranty.

O-RING CARE AND MAINTENANCE

Your 6-series sondes utilize user-accessible o-rings as seals to prevent environmental water from entering the battery compartment and the sensor ports. Please read the following instructions carefully prior to deploying your YSI Sonde. Following the recommended procedure will assure that no problems will occur with regard to water influx into your sonde.

If the o-rings and sealing surfaces on the sondes are not maintained properly, it is possible that water can enter the battery compartment and/or sensor ports of your sonde. If water enters these areas, it can severely damage the battery terminals or probe ports causing loss of battery power during a deployment, false readings and corrosion to the probes. Therefore, when the battery compartment lid is removed from 600XLM, 6920V2-1, 6600V2-2, 6600EDS V2-2, 6600V2-4 and 600 OMS V2-1(battery version) sondes, the o-rings that provide the seal should be carefully inspected for contamination (e.g. hair, grit, etc.) and cleaned if necessary using the instructions provided below. The same inspection should be made of the o-rings associated with the probes, port plugs, and field cable connectors when they are removed. If no dirt or damage to the o-rings is evident, then they should be lightly greased without removal from their groove. However, if there is any indication at all of damage, the o-ring should be replaced with an identical item from the YSI 6570 Maintenance Kit supplied with your sonde. At the time of o-ring replacement, the entire o-ring assembly should be cleaned as described below.

To remove the o-rings:
Use a small, flat-bladed screwdriver or similar blunt-tipped tool to remove the o-ring from its groove. Check the o-ring and the groove for any excess grease or contamination. If contamination is evident, clean the o-ring and nearby plastic parts with lens cleaning tissue or equivalent lint-free cloth. Alcohol can be used to clean the plastic parts, but use only water and mild detergent on the o-ring itself. Also, inspect the o-rings for nicks and imperfections.

CAUTION:
- Using alcohol on o-rings may cause a loss of elasticity and may promote cracking.
- Do not use a sharp object to remove the o-rings. Damage to the o-ring or the groove itself may result.

Before re-installing the o-rings, make sure that you are using a clean workspace, clean hands and are avoiding contact with anything that may leave fibers on the o-ring or grooves. Even a very small bit of contamination (hair, grit, etc.) may cause a leak.

To re-install the o-rings:

- Place a small amount of Teflon stopcock grease between your thumb and index finger. (More grease is NOT BETTER!)

- Draw the o-ring through the grease while pressing the fingers together. Use this action to place a VERY LIGHT covering of grease to all sides of the o-ring. Place the o-ring into its groove making sure that it does not twist or roll.

- Use the previously grease-coated finger to once again lightly go over the mating surface of the o-ring. DO NOT use excess grease on the o-ring or the o-ring groove.

CAUTION: Do not over-grease the o-rings. The excess grease may collect grit particles that can compromise the seal. Excess grease can also cause the waterproofing capabilities of the o-ring to diminish,

potentially causing leaks into the compartment. If excess grease is present, remove it using lens cloth or lint-free cloth.

SONDE PROBE PORTS

Whenever you install, remove or replace a probe, it is extremely important that the entire sonde and all probes be thoroughly dried prior to the removal of a probe or a probe port plug. This will prevent water from entering the port. Once you remove a probe or plug, examine the connector inside the sonde probe port. If any moisture is present, use compressed air to completely dry the connector. If the connector is corroded, return the sonde to your dealer or directly to YSI Technical Support, see **Section 9, Warranty and Service Information**, for details. When you reinstall a probe or port plug, lightly grease the O-ring with lubricant supplied in the YSI 6570 Maintenance Kit.

CABLE CONNECTOR PORT

The cable connector port at the top of the sonde should be covered at all times. While communicating with the sonde, a cable should be installed and tightened in place. This will assure that a proper connection is being made and prevent moisture and contaminants from entering.

When a communications cable is not connected to the cable connector port, the pressure cap supplied with the instrument should be securely tightened in place.

If moisture has entered the connector, dry the connector completely using compressed air, a clean cloth, or paper towel. Apply a very thin coat of lubricant from the 6570 Maintenance Kit to the O-ring inside the connector cap before each installation.

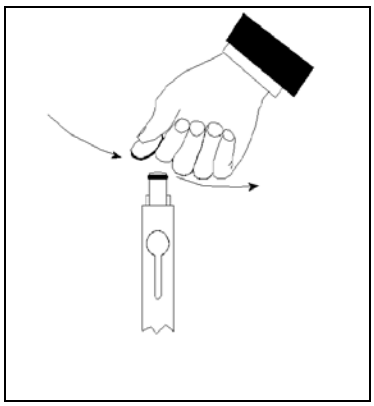
2.10.2 PROBE CARE AND MAINTENANCE

Once the probes have been properly installed, remember that periodic cleaning and DO membrane changes are required.

6562 RAPID PULSE DO PROBES

For best results, we recommend that the KCl solution and the Teflon membrane at the tip of the 6562 probe be changed prior to each sonde deployment and at least once every 30 days during the use of the sonde in sampling studies. In addition, the KCl solution and membrane should be changed if (a) bubbles are visible under the membrane; (b) significant deposits of dried electrolyte are visible on the membrane or the O-ring; and (c) if the probe shows unstable readings or other probe-related symptoms. See Section 2.3 for instructions on changing the DO membrane.

After removing the used membrane from the tip of the 6562 probe, examine the electrodes at the tip of the probe. If either or both of the silver electrodes are black in color, the probe should be resurfaced using the fine sanding disks which are provided in the 6035 reconditioning kit.



To resurface the probe using the fine sanding disk, follow the instructions below.

First dry the probe tip completely with lens cleaning tissue. Next, hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode (located between the two silver electrodes). The motion is similar to that used in striking a match. Usually 10-15 strokes of the sanding disk are sufficient to remove black deposits on the silver electrodes. However, in extreme cases, more sanding may be required to regenerate the original silver surface.

After completing the sanding procedure, repeatedly rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit left by the sanding disk. After cleaning, thoroughly rinse the entire tip of the probe with distilled or deionized water and install a new membrane.

IMPORTANT: Be sure to: (1) Use *only* the fine sanding disks provided in the 6035 maintenance kit in the resurfacing operation and (2) Sand in a direction parallel to the gold electrode. *Not adhering to either of these instructions can seriously damage the electrodes.*

NOTE: If this procedure is unsuccessful, as indicated by improper probe performance, it may be necessary to return the probe to an authorized service center. See **Section 9, Warranty and Service Information**, for contact information.

6150 ROX OPTICAL DO PROBES

CAUTION: The sensor membrane of the 6150 probe should be cleaned ONLY with a lens tissue which has been moistened with WATER. ALCOHOL should NOT be used in the cleaning process as it will dissolve the outer paint layer of the membrane assembly; other organic solvents will likely dissolve the dye itself. Under NO circumstances should you use organic solvents to clean your sensor membrane

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

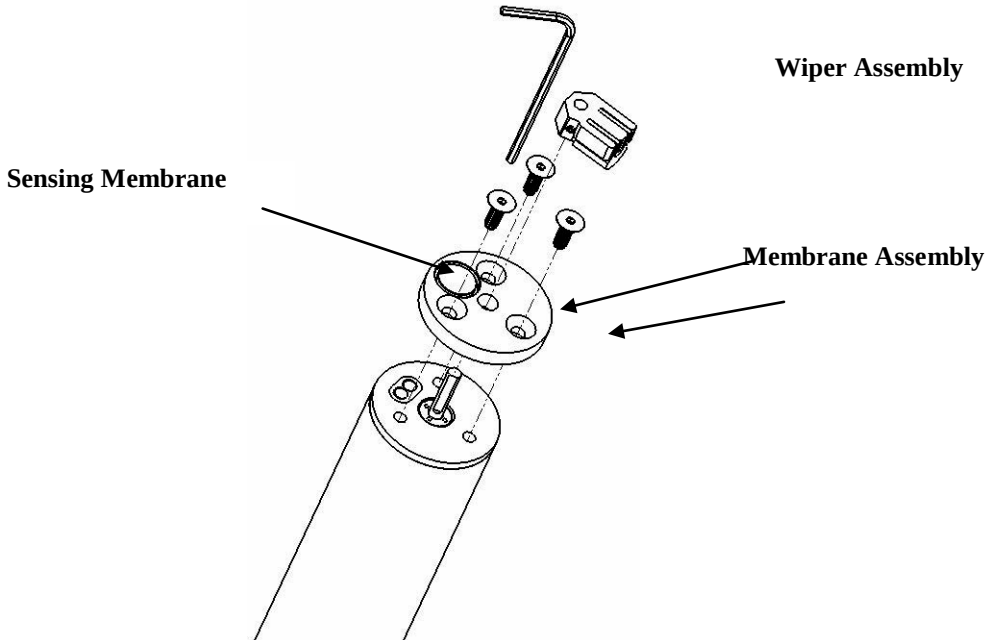
If you inadvertently leave your sensor exposed to ambient air for a period of more than approximately 2 hours, you can rehydrate the membrane by the following method: (1) Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and maintain the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air at room temperature prior to calibration and deployment. **CAUTION: MAKE CERTAIN THAT THE WATER IN THE VESSEL DOES NOT COMPLETELY EVAPORATE DURING THE REHYDRATION STEP.**

YSI recommends the optical DO membrane assembly be replaced once a year in order to assure the maximum accuracy for the sensor and the 6155 kit allows the user to carry out this replacement without returning the sensor to the factory. The following section provides detailed instructions for replacement of the optical DO membrane assembly on the YSI Optical DO sensor.

NOTE CAREFULLY: The 6155 optical sensor membrane has been shipped in a humidified atmosphere and the package SHOULD NOT BE OPENED until immediately before membrane replacement. Once the sensor membrane has been installed on the 6150 DO sensor as described below, it is important to keep the membrane in an environment which is characterized by 100% humidity. Thus, after replacement of the membrane and installation of the sensor system in your sonde, the DO probe with attached membrane should be stored either immersed in water or in a sealed calibration cup which contains enough water so that the atmosphere is water-saturated. See sensor maintenance instructions below if you inadvertently leave the sensor in ambient air for a period of more than 2 hours.

Membrane Installation Instructions

Use the schematic below as an aid in replacement of the YSI Optical DO membrane.



Note: The following steps can be carried out with the probe either installed in the sonde or removed from it. Avoid touching the sensing membrane (shown in the above drawing) during the procedure.

- Remove the wiper assembly from the 6150 Optical DO Sensor and set it aside for later use.
- Using the 1/16 inch hex driver supplied in the 6155 Kit, remove the three screws from the sensor face as shown in the diagram above. Remove the old membrane assembly from the wiper shaft and set the screws aside for later use.
- Remove the new sensor membrane assembly from its hydrated container and dry the backside (the side with the cavity) completely. Be certain that there is no water remaining in the cavity which holds the sensing membrane. Use lens cleaning tissue, a gentle stream of compressed air, or both to assure that the membrane cavity is dry. Do not heat the membrane assembly.
- Make certain that there is an O-ring in place in the groove surrounding the sensor cavity.
- Place the sensor membrane assembly over the wiper shaft and align the holes in the membrane holder with those on the probe face so that the sensor cavity is located over the optical fiber ends on the probe face. Be absolutely certain that the sensor cavity lines up with the probe optics before proceeding.
- Place one of the screws in a hole in the membrane assembly and rotate the assembly slightly as needed to match the screw to the proper hole in the probe face. Partially tighten the screw using the 1/16 inch hex driver.
- Insert screws in the other two holes of the membrane assembly, rotating slightly as needed to match the screw to the hole in the probe face. Partially tighten the screws using the 1/16 inch hex driver. Take care not to scratch the membrane surface.
- Tighten all three screws securely using the 1/16 inch hex driver. CAUTION: INSERT LONG SHAFT OF THE HEX DRIVER INTO THE SCREW AND TURN WITH THE SHORT SHAFT AS SHOWN IN THE DIAGRAM TO AVOID OVERTIGHTENING THE SCREWS.

- Replace the wiper on the probe shaft and tighten with the proper 0.05 inch hex driver.
- **Store the probe with new membrane in either water or water-saturated air as described on the previous page.**

6560 CONDUCTIVITY/TEMPERATURE PROBES

The openings that allow fluid access to the conductivity electrodes must be cleaned regularly. The small cleaning brush included in the 6570 Maintenance Kit is ideal for this purpose. Dip the brush in clean water and insert it into each hole 15-20 times. In the event that deposits have formed on the electrodes, it may be necessary to use a mild detergent with the brush. After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

NOTE: If this procedure is unsuccessful, or if probe performance is impaired, it may be necessary to return the probe to an authorized dealer service center See **Section 9, Warranty and Service Information** for contact information.

The temperature portion of the probe requires no maintenance.

6561/6561FG pH AND 6565/6565FG/6566 COMBINATION pH-ORP PROBES

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these probes or when the response of the probe becomes slow.

Remove the probe from the sonde. Initially, simply use clean tap water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (6561 and 6565) and platinum button (6561). Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

CAUTION: When using a cotton swab with the 6561 or 6565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress. You can also use a pipe cleaner for this operation if more convenient. DO NOT use toothbrush, steel wool, or abrasive cleaners on any glass sensor.

If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 10-15 minutes in clean tap water containing a few drops of commercial dishwashing liquid, or enzyme-containing detergent such as Terg-A-Zyme (by Alconox).

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the probe in clean tap water, wipe with a cotton swab saturated with clean water, and then rerinse with clean tap water.

If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the probe for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. Rinse the probe in clean tap water, wipe with a cotton swab saturated with clean water, and then rerinse with clean tap water. To be certain that all traces of the acid are removed from the probe crevices, soak the probe in pH 4 or 7 buffer for about an hour with occasional stirring.

If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the probe for approximately 1 hour in a 1 to 1 dilution of commercially-available chlorine bleach.

2. Rinse the probe with clean tap water and then soak for at least 1 hour in pH 4 or 7 buffer with occasional stirring to remove residual bleach from the junction. (If possible, soak the probe for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then rerinse the probe with clean tap water and retest.

Dry the sonde port and probe connector with compressed air and apply a very thin coat of O-ring lubricant to all O-rings before re-installation. Keep pH probes moist when not in use but NEVER store in DI water.

DEPTH SENSOR

The depth sensor modules are factory installed options that are located between the bulkhead and the sonde tube. For 600XL and 600XLM sondes, there is a circular protective cap with two small holes. The cap cannot be removed, but a syringe is supplied in the maintenance kit to aid in cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the pressure port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

***CAUTION*:** Never try to remove the circular pressure port cap.

For 6920V2-1, 6920V2-2, 6600V2-2, 6820V2-1and 6600V2-2 sondes, the depth sensor is exposed to the water by either a circular access port on the side of the sonde or a though-hole on a module just above the sonde bulkhead. A syringe is supplied in the maintenance kit to aid cleaning the pressure port. Fill the syringe with clean water, place the tip of the syringe into one of the holes and gently force water through the access port. Ensure that the water comes out of the other hole. Continue flushing the pressure port until the water comes out clean.

***CAUTION*:** Do not attempt to remove the depth module from the sonde body.

LEVEL SENSOR

For level sensors follow all the maintenance procedures given for depth sensors. In addition, ensure that the desiccant always remains active. Active desiccant is a distinctive blue color. When it can absorb no more moisture, it is a rose red or pink color. For either the cartridge or the canister, the end that is vented to atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated well before it is completely exhausted to ensure that it lasts the entire deployment.

You may regenerate the desiccant, replace the desiccant in the cartridge or canister, or replace the entire cartridge or canister. See **Appendix G, Using Vented Level**, for more information.

To regenerate the desiccant, remove it from the unit and spread it evenly, one granule deep, on a suitable tray. Heat for about one hour at about 200° C (about 400° F). The desiccant should then be cooled in a

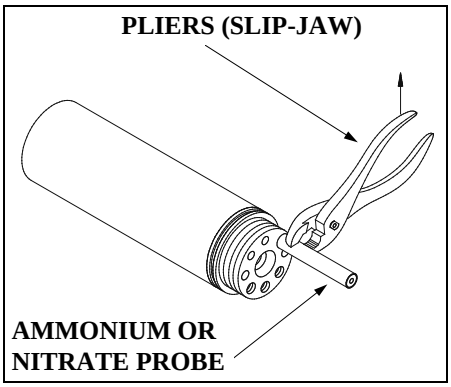
suitable, tight container before refilling the unit. The color of the desiccant will return to blue if the regeneration cycle has been successful. The felt filters should also be dried at about 100° C (about 200° F) for about 30 minutes before assembly.

Desiccant material is sold separately. Both the cartridge and canister can easily be opened, emptied, and refilled.

***CAUTION*:** It is important to keep the tube in vented sondes and cables dry. They are supplied with caps for closing the volume when not in use. Keep the caps on until just before calibration and deployment. For storage, replace the caps.

6882 CHLORIDE, 6883 NITRATE AND 6884 AMMONIUM SENSORS

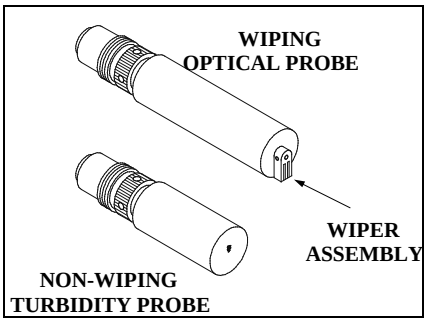
You should clean these probes whenever deposits or contaminants appear on the ion selective membranes located on the tips of these sensor modules. If possible, the module should be cleaned while installed in the sonde bulkhead. Use clean water and a moist piece of lens cleaning tissue to *gently* wipe the sensor membranes until no more contaminants are removed. However, under some conditions, it may be necessary to remove the module from the sonde bulkhead for cleaning and/or storage. To remove the module, follow the diagram at the side. Remove the module with finger pressure only, if possible. However, it is acceptable to use small pliers if necessary to loosen the module for final removal by hand. **Be very careful not to squeeze the module any more than is necessary for a firm grip. Use slipjaw pliers to minimize the chance of applying too much pressure on the module**. While the module is removed from the sonde, be sure to dry the sonde port and probe connector with compressed air and apply a very thin coat of lubricant to the O-ring before re-installation.



NOTE: The ion selective membranes are fragile. Be certain to: (1) Use only *moist*, high quality lens cleaning tissue for the cleaning procedure (not paper towels or other coarse materials); and (2) Stroke the probe face very gently with the tissue during the procedure. *If you do not adhere to these instructions, you can seriously damage the sensors.*

OPTICAL PROBES–6026 AND 6136 TURBIDITY; 6025 CHLOROPHYLL; 6131 BGA-PC; 6132 BGA-PE; 6130 RHODAMINE WT

The 6026, 6136, 6025, 6131, 6132, and 6130 probes require only minimal maintenance. After each deployment, the optical surface on the tip of the turbidity probe should be inspected for fouling and cleaned if necessary by gently wiping the probe face with moist lens cleaning paper. In addition, for the 6025, 6026, 6136, and 6130 probes, we recommended replacing the wiper periodically. The frequency of this replacement depends on the quality of water under examination. A replacement wiper is supplied with the probes, along with the small hex driver required for its removal and reinstallation. Follow the instructions supplied with the probe to ensure proper installation of the new wiper assembly. Additional wipers are available from YSI.



2.10.3 SONDE STORAGE

Proper storage of the your sonde between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

GENERAL RECOMMENDATIONS FOR SHORT TERM STORAGE

The recommended short term or interim storage procedure is simple and identical for all sondes -- YSI 600R, 600QS, 600XL, 600XLM, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, and 600 OMS V2-1.

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid, which could cause some of them to drift or result in a shorter lifetime. For example, the reference junction of a pH sensor must be kept moist in pH 4 or 7 buffer, or tap water, to minimize its response time during usage, but continued immersion in pure water will compromise the function of the glass sensor and/or result in long term leaching of the reference junction.

YSI recommends that short term storage of all multi parameter instruments be done **by placing approximately 0.5 inch of water in the calibration and/or storage cup that was supplied with the instrument, and by placing the sonde with all of the probes in place into the cup.** The use of a moist sponge instead of a half inch of water, is also acceptable, as long as its presence does not compromise the attachment of the calibration cup to the sonde. **The calibration cup should be sealed to prevent evaporation.**

The key for interim storage is to use a minimal amount of water so that the air in chamber remains at 100 percent humidity. The water level has to be low enough so that none of the sensors are actually immersed. Any type of water can be used in this protocol: Distilled, deionized, or tap water. If the storage water is inadvertently lost during field sampling studies, environmental water can be used to provide the humidity.

Sondes with level sensors have a tube that vents the pressure transducer to the atmosphere**. It is important that the air in the tube remains dry at all times.** Sondes with integral cables should be stored with the desiccant in place and the vented end of the desiccant system sealed. Sondes with connectors should be stored with the connector cap firmly in place. When disconnecting the cable, put the cap on immediately. Vented cables should be stored with their caps in place, in a bag containing desiccant.

Interim multi parameter storage is easy. Simply remember the following key points:

- Use enough water to provide humidity, but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.
- Check the vessel periodically to make certain that water is still present.
- For sondes with level sensors, keep the tube sealed and dry.

GENERAL RECOMMENDATIONS FOR LONG-TERM SONDE STORAGE

The following are long term storage recommendations listed by instrument type. They will be applicable for sondes with typical sensor configurations.

600XL, 600XLM -- Remove the pH or pH/ORP probe from the sonde and store it according to the instructions found in the following section on individual sensors. Cover the empty port with the provided plug. Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and seal with the cap/O-ring to minimize evaporation.

6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 -- Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane and electrolyte on the DO sensor. Remove all other probes from the sonde and store according to the instructions found in the following section on individual sensors. Cover the empty ports with the provided plugs. Place enough of deionized, distilled, or tap water in the calibration cup to cover the sensors, insert the sonde into the vessel, and tighten the threaded cup to attain a good seal and minimize evaporation.

600R and 600QS (with Replaceable Reference Electrode Module) -- Instruments of this design were generally sold after January, 1996 and can be identified by the presence of 4 probes -- temperature, dissolved oxygen, pH reference, and pH glass (600R) or pH glass/ORP (600QS) in the bulkhead. Remove the reference module, store it as described below, and plug the open port with the insert that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Place approximately 300 mL of tap water in the storage vessel, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.**

600 (with Combination pH Sensor) -- Instruments of this design were generally sold prior to January, 1996 and can be identified by the presence of only 3 probes (temperature, dissolved oxygen, pH) in the bulkhead. Be certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution that is 2 molar (2 M) in potassium chloride (KCl) to a level that completely covers the dissolved oxygen and pH probes. See the following section for instructions on preparation of the KCl storage solution. Seal the vessel with the cap and O-ring.

600 OMS V2-1 – Store sonde dry with optical probe left in port. Cover membrane on ROX sensor with moist sponge.

All Sondes with Batteries – Because batteries can degrade over time and release battery fluid, it is extremely important to remove the batteries from all 600XLM, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, 6600V2-4, and 600 OMS V2-1(battery version) prior to long term storage. Failure to remove batteries can result in corrosive damage to the battery terminals if the batteries happen to leak.

2.10.4 PROBE STORAGE

LONG-TERM STORAGE OF PROBES

The following sections provide additional details on the storage of individual sensors associated with instruments in the 6-Series product line from YSI.

TEMPERATURE

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with the thermistor probe are not corrosive (for example, chlorine bleach).

CONDUCTIVITY

No special precautions are required. Sensors can be stored dry or wet, as long as solutions in contact with thermistor probe and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage.

RAPID PULSE DISSOLVED OXYGEN

Rapid Pulse dissolved oxygen sensors should always be stored with a membrane and electrolyte in place and in such a way that the drying out of the electrolyte on the probe face is minimized. For long-term storage, the medium should be water rather than the moist air used in interim storage. The long-term storage protocol is also dependent on the instrument under consideration.

ROX dissolved oxygen sensors should always be stored in a moist environment, i.e., either in water or in water-saturated air with storage in water being preferable. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

For all 6-series sondes other than the 600R, 600QS, and 600 OMS V2-1, two long-term storage methods are equally acceptable.

1. Remove all probes other than dissolved oxygen (Rapid Pulse or ROX), conductivity, and temperature from the sonde and seal the vacant ports with the provided port plugs. Leave the electrolyte and membrane in place on the Rapid Pulse dissolved oxygen sensor. Fill the calibration cup with water (tap, deionized, or distilled are equally acceptable) and insert the sonde. Make certain the water level is high enough to completely cover the DO sensor. Seal the vessel to prevent evaporation of the water. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

2. Remove the Rapid Pulse dissolved oxygen sensor from the sonde leaving the electrolyte and membrane in place. Store the probes in water (tap, deionized, or distilled are equally acceptable) in a beaker, flask, or other vessel of the user's choice. **Be sure not to damage the membrane or the probe tip when placing the probe on the bottom of the vessel.** If possible cover the vessel with parafilm or plastic wrap to minimize evaporation of the water during long-term storage. Monitor the water level in the storage vessel periodically and replenish if loss due to evaporation occurs. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

Because the user cannot remove the dissolved oxygen probe of the 600R and 600QS from the sonde, a slightly different long-term storage protocol is required:

For 600 systems equipped with a replaceable reference electrode module, remove the reference module, store it as described below and plug the open port with the port plug that was provided. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided storage vessel with a solution which is 2 molar (2 M) in potassium chloride (KCl), insert the sonde and seal the vessel with the cap and O-ring. This solution can be prepared by dissolving 74.6 g of KCl in 500 mL (approximately 1 pint) of water or 37.3 g of KCl in 250 mL (approximately 0.5 pint) of water. The water should be distilled or deionized. If KCl solution is unavailable, it is acceptable to store the dissolved oxygen and pH glass sensors in tap water. **Do not use deionized or distilled water in this case, as it may**

damage the pH glass sensor, which must remain in the sonde. At the end of the storage time, remove the existing membrane and re-membrane the probe using new electrolyte.

ROX OPTICAL DISSOLVED OXYGEN

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

pH

The key to pH probe storage, short or long-term, is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride (see dissolved oxygen section above for preparation of this solution). If potassium chloride solution is not available, soaking the sensor in commercial pH buffers or tap water may restore probe function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement. It is also important to remember not to store the pH sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

The long-term storage protocol is dependent on the instrument.

For all YSI 6-series sondes other than the 600R and 600QS, the recommended long-term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride, or pH 4 or 7 buffer. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

For YSI 600R and 600QS sondes, remove the reference module and plug the open port with the provided insert. Place the module in the storage vessel boot, which was in place on delivery, and seal the vessel with electrical tape. The vessel should contain a solution which is 2 molar in potassium chloride and should be sealed to prevent evaporation of the storage solution. Make certain that the dissolved oxygen sensor has an undamaged membrane and electrolyte in place. Fill the provided sonde storage vessel with tap water, insert the sonde, and seal the vessel with the cap and O-ring. **Do not use deionized or distilled water in this case, as it may damage the pH glass sensor that must remain in the sonde.**

ORP

Long Term Storage: ORP is not available on the YSI 600R. For the 600QS, where the ORP sensor cannot be removed from the sonde, store the sensor in tap water in a sealed storage bottle. For all other YSI 6-series sondes, the recommended long term storage protocol is identical. Remove the probe from the sonde and seal the vacant port with the provided plug. Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a solution which is 2 molar in potassium chloride. Make certain that the vessel is sealed to prevent evaporation of the storage solution.

AMMONIUM, NITRATE AND CHLORIDE

The active element in the ammonium and nitrate ion selective electrode (ISE) sensors is a polyvinyl chloride (PVC) membrane that is impregnated with the reagent that provides specificity for either ammonium or nitrate. The useful life of this sensor can be reduced if the membrane is stored immersed in water. Thus, storage in dry air is recommended for long term storage. While dry air is slightly preferable for general storage, the short-term storage of these sensors in the sonde, with the entire sensor array in moist air, will have no significant detrimental effect on the life of the membrane. Remove the sensor module from the sonde and cover the vacant port with the provided plug. Place the sensor back in the storage boot that was provided, and set aside in room air.

The chloride ISE sensor utilizes a solid state membrane that provides specificity. For long-term storage, the module should be removed from the sonde, wiped clean with moist lens cleaning tissue, and placed in its storage boot to prevent abrasion.

TURBIDITY, CHLORPHYLL, BGA-PC, BGA-PE, AND RHODAMINE WT

No special precautions are necessary for either the short or long-term storage of these YSI optical probes. However, for long-term storage, the user may wish to remove the probe from the sonde, replace it with a port plug, and store the probe in dry in air to minimize any cosmetic degradation of the probe body and to maximize the life of the wiper.

DEPTH AND LEVEL

No special precautions are required for the sensor itself, but see instructions above with regard to maintaining a dry atmosphere in the vent tube. Sensors can be stored dry or wet, as long as solutions in contact with the strain gauge sensor port are not corrosive (for example, chlorine bleach).

Recommendations are identical for short-term and long-term storage.

SECTION 3 650 MDS DISPLAY/LOGGER

3.1 INTRODUCTION

The YSI 650 Multiparameter Display System (650 MDS) is a powerful, hand held microcomputer based instrument that allows the user to display sonde readings, configure sondes, store and recall data, upload data from sondes and transfer data to computers for analysis and plotting.

Key features of the YSI 650 MDS:

- Completely waterproof case that is submersible to 1 m. Meets IP-67 specification.
- Rugged design with high impact resistance
- Large, non-volatile memory
- Simple cellular phone style keypad.
- Simple intuitive user-interface
- Choice of alkaline batteries or optional rechargeable battery pack
- Fuel gauge display of battery capacity
- User selectable backlight
- Handstrap (standard) or hands free harness (optional) for user comfort
- Optional barometer
- Optional GPS interface
- Compatibility with YSI EcoWatch for Windows data analysis software
- User upgradeable software via the YSI Web page
- CE and Australian C-Tick Compliance.

Partnered with a YSI 6-Series sonde, the 650 will allow the user to easily:

- Display real-time readings from YSI 6-series sondes.
- Log real-time sonde data to internal meter memory with custom site lists.
- Calibrate 6-series sondes.
- Set up 6-series sondes for deployment.
- Upload data from sondes for transfer to PC.

3.2 GETTING STARTED

This section is designed to quickly familiarize you with the hardware and software components of the YSI 650 and its accessories. By the end of Section 3.2 you will have...

- Unpacked the YSI 650 and confirmed that all components are present
- Become familiar with the general features and setup configurations of your YSI 650.
- Installed batteries in the YSI 650.
- Established communication between your 6-series sonde and the YSI 650.
- Viewed data from your 6-series sonde on the YSI 650 display.
- Learned the basics of making alphanumeric entries from the keypad by setting the YSI 650 clock and entering an Instrument ID name.

Successful completion of the above list is essential for you to continue on to Section 3.3, which focuses on the custom setup of the 650. In subsequent sections, you will learn about how to set up sonde menus via the 650 interface, log data to both sonde and 650 memories, and use the GPS and barometer features of the 650.

3.2.1 UNPACKING

Remove the instrument from the shipping box, being careful not to discard any parts or supplies. Use the packing list to ensure all items are included, and inspect all assemblies and components for damage. If any parts are damaged or missing, contact your YSI representative immediately. If you do not know which YSI dealer you obtained your YSI 650 from, refer to Section 8 of your 6-series sonde manual for contact information.

The 650 is offered in four configurations:

- 650-01 – Low memory with no barometer
- 650-02 – High memory with no barometer
- 650-03 – Low memory with barometer
- 650-04 – High memory with barometer

All configurations include the 650 with hand strap and strain relief lanyard installed and the 655174 PC interface cable for use in data transfer to a PC and software updates from a PC. Make certain that you have received these two items (650 itself and PC Interface Cable) during the unpacking process.

The following optional accessories are offered for use with the 650.

- 6113 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6114 110 volt wall charger, and 6117 battery pack included
- 6126 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, European power cable, British power cable, and 6117 battery pack included
- 6127 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, China/Australia power cord, and 6117 battery pack included
- 4654 Tripod
- 614 Ultra Clamp
- 5085 Hands Free Harness
- 5065 Form-fitting Case
- 6117 Extra Rechargeable Battery Pack
- 6115 GPS Cable for interface with user-supplied GPS unit
- 616 Cigarette Lighter Charger

If you have ordered any of these accessories with your 650, make certain during the unpacking process that you have received them.

3.2.2 UNDERSTANDING THE 650 MEMORY

The 650 is available with two memory options – “low” and “high”.

The less expensive low memory option (650-01 and 650-03) is designed for users who typically use their 6-series sondes in sampling applications and store limited data to their logger. The available memory of the low memory option (ca. 10 kB) will allow the user to log approximately 150 field readings to a single file in the 650 although the exact logging capability is dependent on the number of parameters active in the 6-series sonde. Note also that if multiple files are utilized, the number of logged field readings will be reduced. In addition, the low memory option will also allow the user to upload small files to the 650 that have been logged to the internal memory of sondes during **Discrete** or **Unattended sampling** studies.

The high memory option (1.5 mB) of the 650 is designed for users who log large files directly to the 650 or who wish to upload large (or many) files to the 650 from the internal memory of sondes which have been used to log data in **Discrete or Unattended sampling** applications. For example, with the high memory option, it would be possible to easily upload the data from 7 sondes, each of which have data files in excess of 200 kB or approximately 75 days at a 15-minute unattended sampling interval.

No matter which memory option has been selected, it is important to understand that the memory resident in the 650 is "Flash", the same type of memory present in YSI 6-series sondes. Flash memory requires no battery backup and therefore stored data cannot be lost due to instrument malfunction – a significant advantage. However, it is not possible to erase individual files from flash memory – to free-up memory, the user must erase (or format) the entire memory chip. From a practical point of view, this means that, while named files which are already present in the 650 memory can be "overwritten" during multiple uploads, the previously written files still occupy space in the memory. These files are in fact designated "deleted" as will be described in Section 3.6.5 below. For example, if a file named "TEST" is uploaded initially with a memory allocation of 50 kB and then is uploaded at a later time (and "overwritten") with a memory allocation of 100 kB, the total memory occupied is 150 KB even though only one file with the designation "TEST" and a file size of 100 kB is shown in the file directory. For this reason, when dealing with large files, the user may wish to transfer files to a PC immediately after upload and then erase the entire flash in order to assure that maximum memory is present for subsequent uploads.

The storing of data directly from sondes to the 650 memory, the uploading of data stored in 6-series sondes to the 650, and the management of these data files are described in detail in Sections 3.5, 3.6, and 3.7 of this manual.

3.2.3 650 CONFIGURATIONS

There are a number of ways that you can configure the YSI 650. Below is a list of possible configurations and corresponding diagrams.

- 650 interfaced to a 6-Series sonde.
- 650 interfaced to a 6-Series Sonde and a user-supplied GPS unit.
- 650 interfaced to a PC for data transfer or software upgrade using the PC interface cable
- 650 with rechargeable battery pack being charged

Figure 1. 650 interfaced to a 6-series sonde.

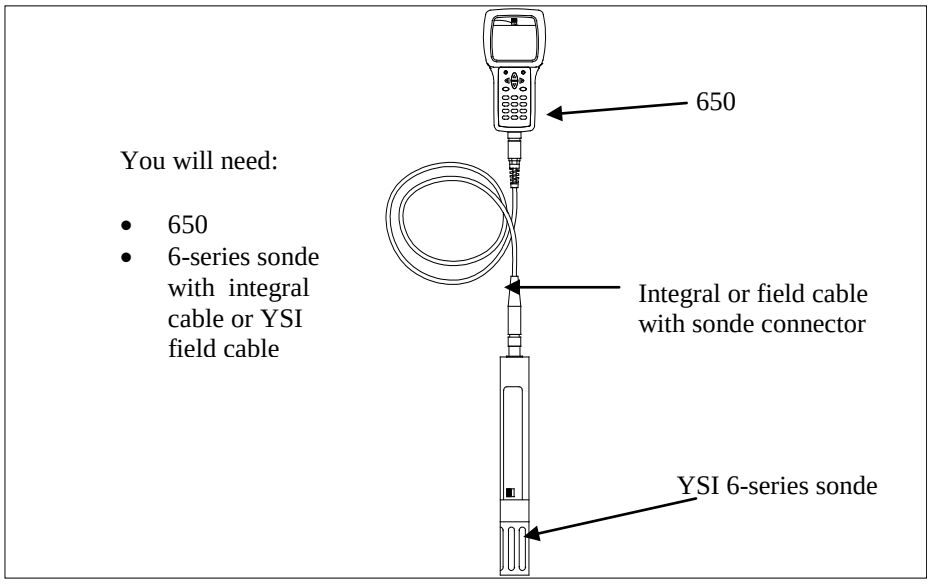


Figure 2. 650 interfaced to a 6-series sonde with user-supplied GPS.

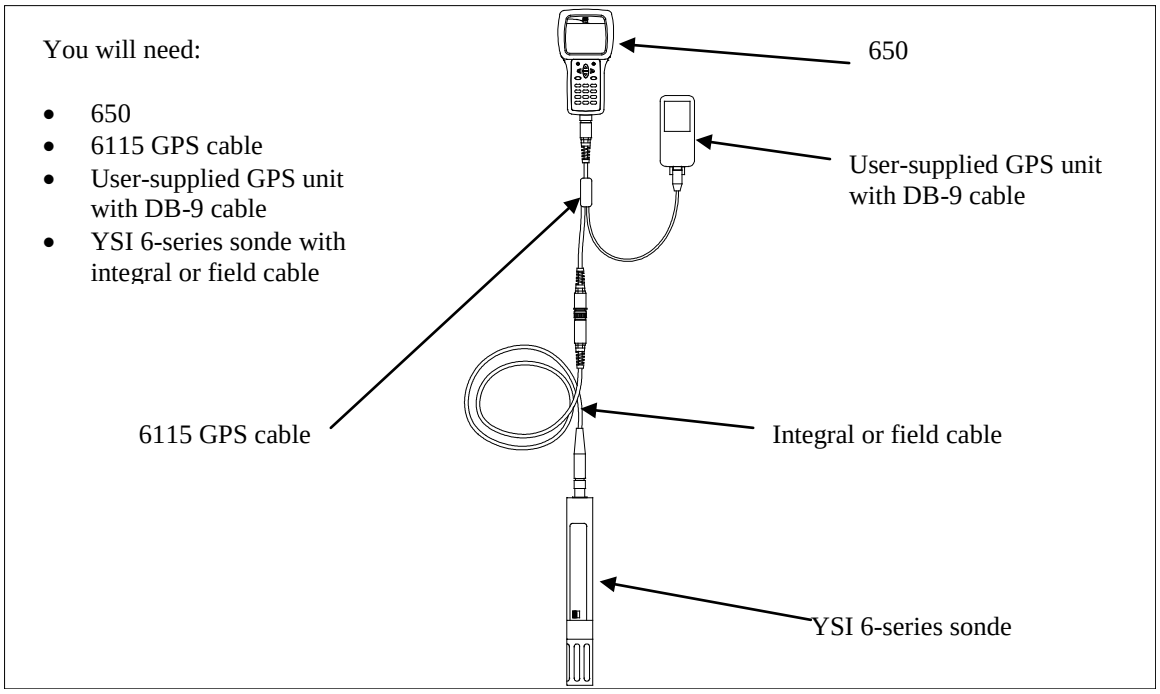


Figure 3. 650 interfaced to PC for data transfer or software upgrade.

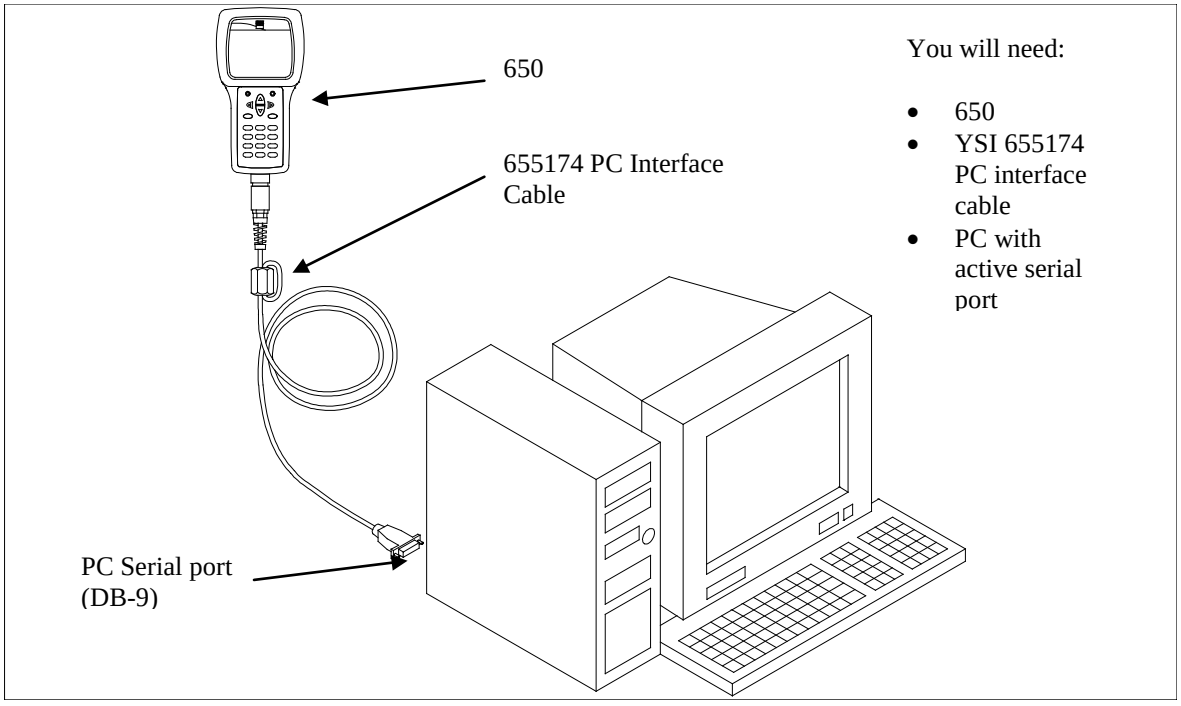
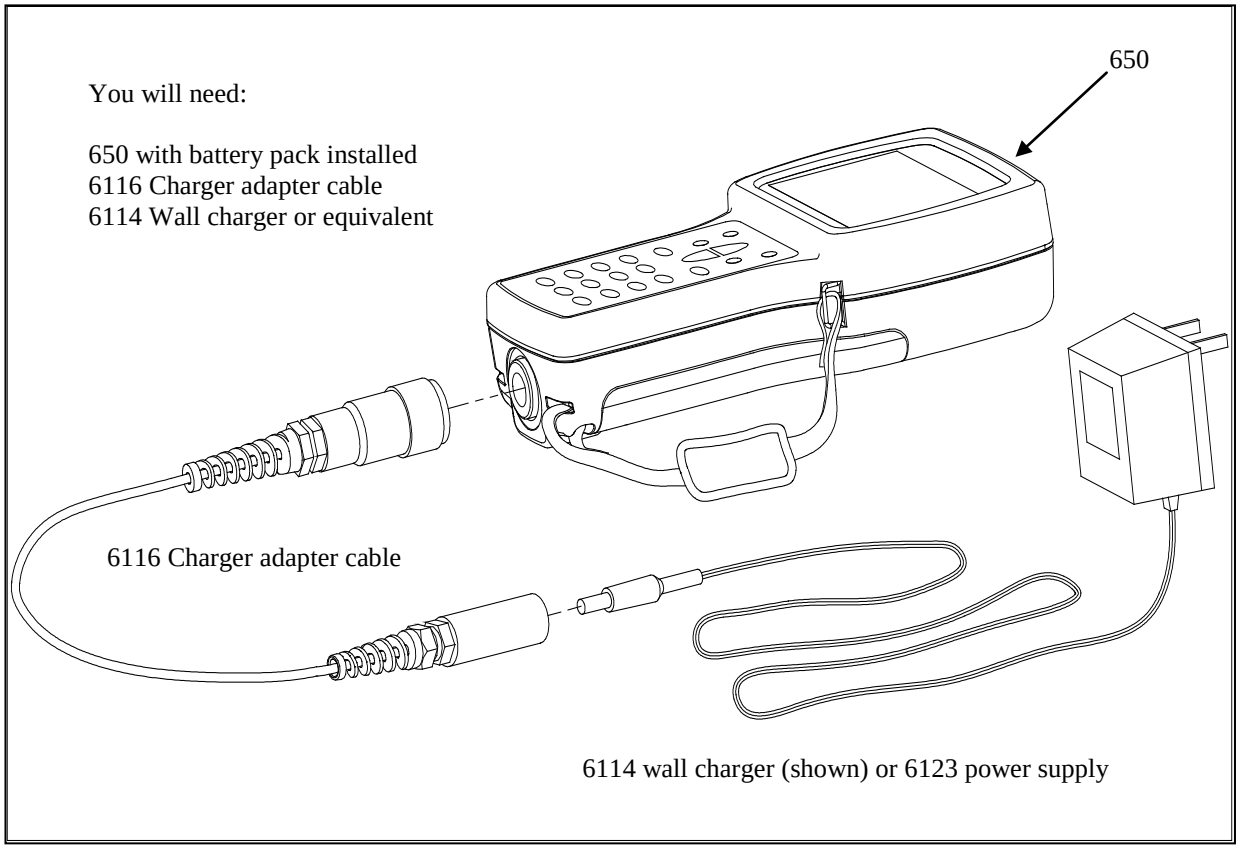


Figure 4. Charging of 650 rechargeable battery pack.



The setup of these configurations is described in detail in subsequent sections of this manual. They are presented here so that your will be able to ascertain if you have all of the parts necessary for your applications.

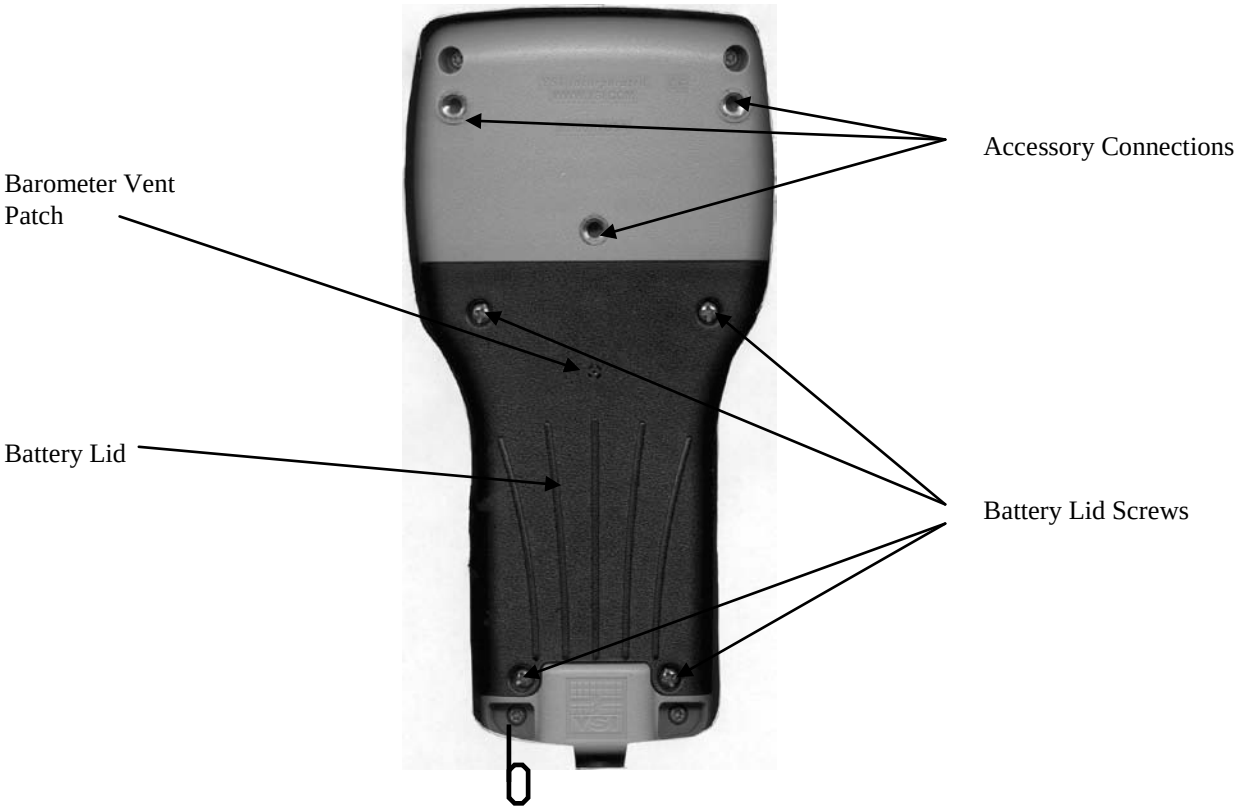
3.2.4 650 FEATURES

The key physical features of the 650 display and keypad are shown in the figures below.

650 Front View

Note that the YSI 650 keypad consists of 20 keys as shown in the diagram above. There are four function keys, up, down, right and left arrow keys and an alpha/numeric keypad. The top left key that has a green circle and line, , is the ON/OFF key. The top right key, , activates the display backlight. The **Escape** key is labeled and is the **Enter** key.

650 Back View



Note that the back of the case contains the battery lid that is attached to the main case with four captive screws and has three fittings for attachment of the ultraclamp and tripod accessories. In addition, the battery lid has a hole that is covered with water-impermeable patch for venting of the optional barometer.

CAUTION: The barometer-venting patch is resident on the inside of the battery lid. Removal of or damage to this patch will result in water leakage into the battery compartment.

The short cord with loop (lanyard) which is attached to the bottom of the case is attached to the strain relief of the sonde cable. Simply open the D-ring, pass the lanyard loop through the opening, and then close the D-ring.

3.2.5 BATTERIES AND CHARGING

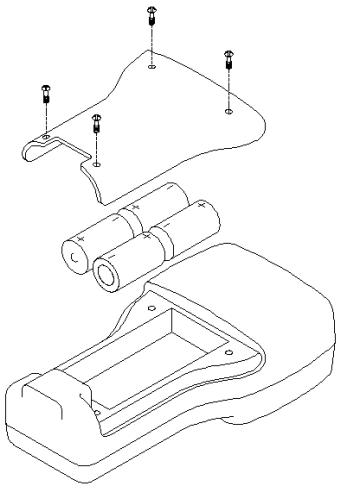
The YSI 650 can be powered either with 4 alkaline C cells or a rechargeable NiMH battery pack. With the C-cell configuration, the user will be able to power a typical YSI 6-series sonde (active dissolved oxygen and one optical sensor) for approximately 45 hours of continuous operation. The rechargeable battery pack will allow for about 15 hours of continuous use under these conditions. If the sonde is being powered by its own internal batteries, the 650 batteries will last much longer. YSI Sondes with internal battery capability are the 6920, 6600, 600XLM, and 600 OMS.

This instrument is powered by alkaline or optional nickel-metal hydride batteries, which the user must remove and dispose of when the batteries no longer power the instrument. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in this instrument contains a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized YSI service center will remove this battery and properly dispose of it, per service and repair policies.

3.2.5.1 BATTERY INSTALLATION – C CELLS

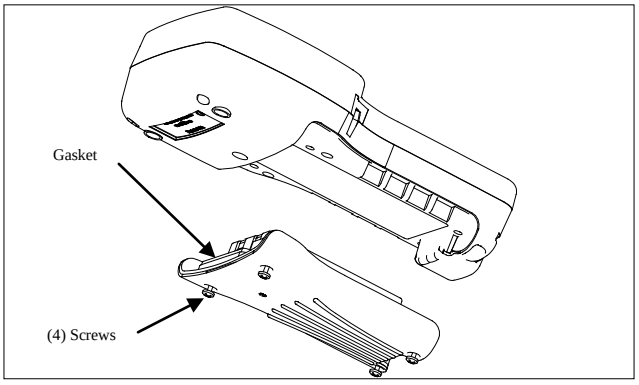
Four C cells install easily into the back of the 650. Follow the instructions and diagrams below to install the batteries properly:



- Using a Phillips or slotted screwdriver, loosen the 4 captive screws on the battery lid and then remove the battery lid completely.
- Insert the cells between the battery clips, being sure to follow the polarity (+ and -) as indicated on the bottom of the battery compartment.
- Make certain that the gasket is properly installed on the battery lid before reinstallation.
- Reinstall battery lid and tighten the 4 captive screws securely and evenly using a Phillips or slotted screwdriver. Do not overtighten.

3.2.5.2 BATTERY INSTALLATION – RECHARGEABLE BATTERY PACK

The YSI 6113 rechargeable battery pack is self-contained and is easily installed according to the instructions and diagrams below:



- Using a Phillips or slotted screwdriver, loosen the 4 captive screws on the battery lid and then remove the battery lid completely.
- Put the battery lid in a safe place so that it will be available for future use of C cells.

- Make certain that the gasket is properly installed on the rechargeable battery before installation.

- Insert the rechargeable battery pack assembly into the battery compartment of the 650.

- Tighten the 4 captive screws securely and evenly using a Phillips or slotted screwdriver. Do not overtighten

3.2.5.3 BATTERY CHARGING – RECHARGEABLE BATTERY PACK

The 6117 rechargeable battery pack is charged via the MS-8 connector on the bottom of the instrument and thus the pack must be installed in the 650 for charging. To perform the charging operation, the user will need to locate the proper power supply (6114 for US/Canada/Japan or 6123 with proper power cord for all other countries) and the 6116 charger adapter cable which were supplied with your rechargeable battery pack (6113 for US/Canada, 6126 for Europe, 6127 for China/Australia). As shown in Figure 4 above, first attach the charger adapter cable to the 650, then insert the barrel connector of the power supply into the barrel of the adapter cable, and finally plug the power supply into an appropriate AC power outlet. The pack can be recharged with the 650 either "on "or "off". However, if the instrument is "on", the progress of the charging operation can be viewed in the Status Bar (see Section 3.2.10 below).

To ensure that you get maximum operational time from the rechargeable battery pack, the user should follow the procedures below:

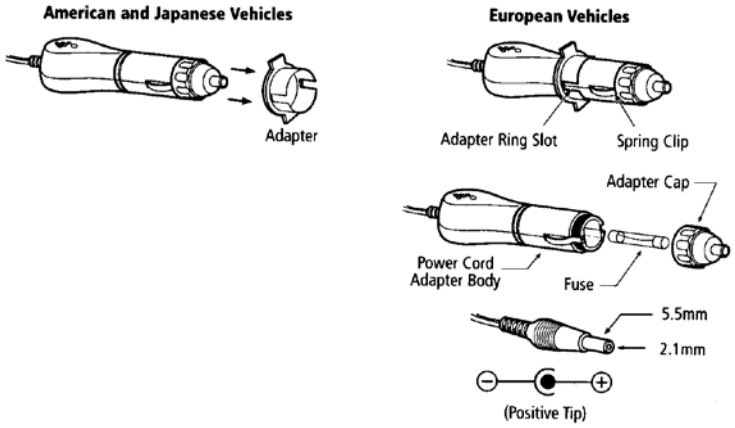
1. Place your display/logger on charge for approximately 2 hours to obtain an 80-90 % regeneration of battery capacity.
2. Place your display/logger on charge for approximately 6 hours to get a full charge.
3. Do not charge the batteries continuously for more than 48 hours.
4. For long term storage, keep your battery pack between the temperatures of –20 C and 30 C and remove it from the 650 case.
5. Do not charge your batteries at temperatures below 0 C or above 40 C.
6. Do not use or store the battery pack at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.

If the above steps are not followed, it may result in a decrease in the operational lifetime of your battery pack. In addition, pay particular attention to the method of long term storage of the battery pack as is outlined in the following warning:

CAUTION: If the battery pack/650 will not be used for extended periods of time, the user should remove the battery pack from the instrument. Failure to do this may result in overdischarge of the pack which can have a detrimental effect of its lifetime

Note that YSI provides recharge options for many countries in the selection or the 6116, 6126, and 6127 kits. However, it is possible that the power cord options in these kits will not be correct for some users. In these cases, users should purchase the 6126 or 6127 kit and substitute their local PC type power cord for the power cord shipped with the kit. This power cord is usually readily available at any local electronics store.

An optional automotive cigarette lighter charger (YSI 616) is also available for recharging the 650 battery pack. Note that the user will require the 6116 adapter cable to use the cigarette lighter adapter. Instructions and diagrams for configuring your cigarette lighter charger and changing fuses are shown below and are found on the back of the 616 package. The user should save these instructions when unpacking the accessory and keep them for later reference.



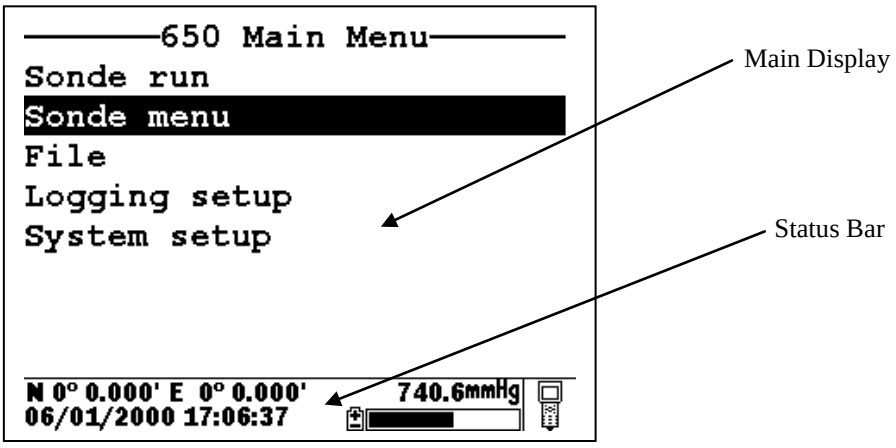
To use the device with an American or Japanese vehicle, slide the adapter ring off of the plug. To use the device with a European vehicle, leave the adapter ring on the plug and position it so the slots on the ring line up with the plug's spring clips. To begin charging your battery pack, first plug the barrel connector of the cigarette lighter charger into the mating end of the 6116 adapter cable. Then attach the MS-8 end of the 6116 adapter cable to the 650. Finally, plug the other end of the cigarette lighter charger into the vehicle's lighter socket.

The 616 cigarette lighter charger contains a 2-ampere fast-blow type fuse. If the power cord stops working properly, unscrew the adapter's cap, remove the tip, and then pull out and check the fuse. See diagram above to remove the fuse. If the fuse is blown or you are unsure, replace it with a new 2-amp fast-blow fuse that is available at electronics stores such as Radio Shack. Reassemble the adapter and securely screw the cap back onto the adapter body.

After you have installed batteries or the rechargeable battery pack into your 650, you are ready to proceed to the next sections.

3.2.6 TURNING THE INSTRUMENT ON

Turn the instrument on by pressing and releasing the on/off button on the top left of the instrument keypad. The following screen should be displayed.



Note that the screen is divided into two sections – the "Main Display" at the top and a "Status Bar" at the bottom. The Main Display will provide access to the 650 and sonde menus and will be used to view sonde sensor readings in real-time, to configure the 650 and the sonde, to calibrate the sonde sensors, and to log data to either sonde or 650 memory. The Status Bar will always show the date and time of the 650 clock (updated in real-time), the remaining battery capacity, the current barometer reading if you have purchased this option, the GPS readings from a user-supplied GPS instrument, and will indicate whether the menu being viewed in the Main Display is associated with your sonde or the 650. Additional information about the Status Bar will be provided in Section 3.2.10 of this manual.

You may also want to take the instrument into a dark room and, with the instrument turned ON, press the backlight key which is located at the top right of the keypad. The instrument backlight should illuminate the LCD so that the display can be read. Pushing the backlight key again will turn the backlight off. The backlight will power off automatically after two minutes of non-use.

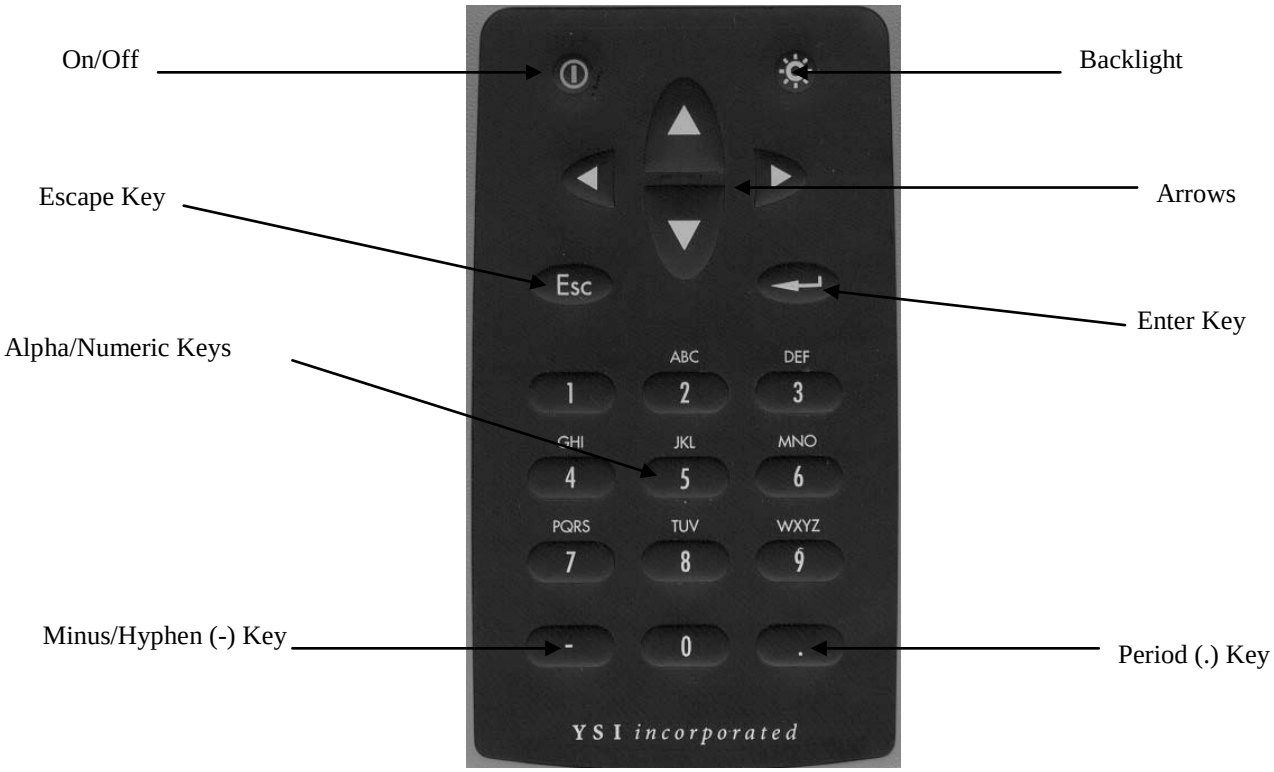
3.2.7 ADJUSTING THE DISPLAY CONTRAST

The contrast of the 650 display is automatically temperature compensated to provide a proper display under most field conditions (-10 to 40 C). Some users, however, may wish to alter the display contrast to meet their own preference. In addition, if the instrument is used at more extreme temperatures, the display is likely to require some adjustment.

The contrast is easily adjusted by pressing and holding down the backlight key in the upper right of the keypad and then pressing repeatedly or holding down the up/down arrow keys while observing the display. Pressing the up arrow while holding down the backlight key increases (darkens) the contrast; pressing the down arrow under these conditions decreases (lightens) the contrast.

NOTE: The backlight itself will only be activated if the backlight key is pressed and released. You must hold down the backlight key to adjust the contrast.

3.2.8 USING THE YSI 650 KEYPAD



The 650 keypad allows the user to navigate various sonde and 650 menu selections and to make alpha/numeric entries into both the 650 and sonde software. The arrow keys are used to select various options in the menus; the cellular phone-style alpha/numeric keys allow data entry; the **Enter** key is used to confirm selections; and the **Escape** key returns the user to the previous position in the menu structure.

The alpha/numeric keys of the 650 can be used to enter both numbers and letters. For many entries, however, where only numbers are appropriate, the software automatically allows ONLY numeric entry, e.g., the letters (ABC) associated with the "2" key cannot be activated. Examples of this type of fixed numeric entry include setting the clock of the 650 or sonde, entering calibration parameters for sonde sensors, and changing entries such as DO warm-up time and optical wiper interval in the **Sonde Advanced|Sensor** submenu. You will follow an example of this type of entry when you set the 650 clock in the example below.

When both numeric and alpha entry are appropriate for input, the 650 keypad provides a cellular phone-style interface for choosing the proper character. As shown in the above diagram, the 2-9 keys can also be used to input alpha characters. Basically, to activate a particular alpha/numeric character, the user must press the appropriate key repeatedly until the desired letter or number appears in the display. For example, to enter an M, press the numeric 6 key once and release. To enter an N, press the numeric 6 key twice in rapid succession and then release. Lower case letters are also available for input using this basic method. The following chart shows the alpha/numeric sequence available for each numeric key in the order they will appear as the key is pressed repeatedly.

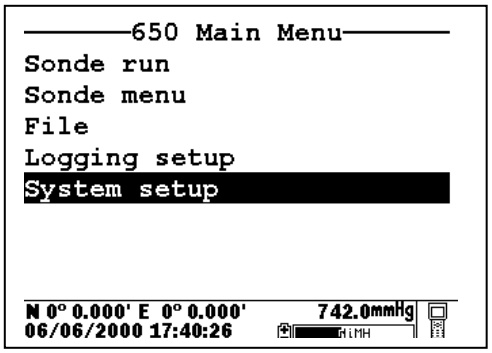
1 -- 1
2 – ABC2abc2
3 – DEF3def3
4 – GHI4ghi4
5 – JKL5jkl5
6 – MNO6mno6
7 – PQRS7pqrs7
8 – TUV8tuv8
9 – WXYZ9wxyz9
0 -- 0

Using this guide, it can be seen that the character "p" will appear and remain in the display by pressing the 7 key six times in succession. The other characters associated with this key ("P", "Q", "R", "S", and "7") will appear during the repeated pressing of the numeric 7 key. However, only the "p" entry will be retained after the key is released after the six keystrokes.

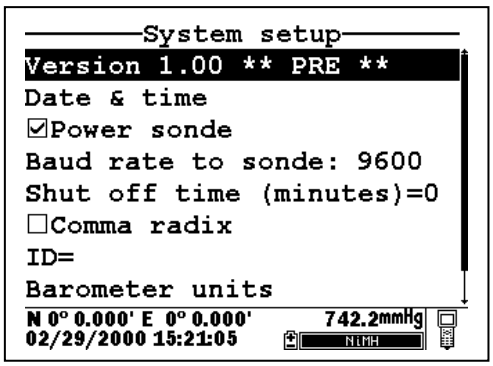
After release of the numeric key for approximately 1second, the cursor will automatically scroll to the right to prepare for the next alphanumeric input. If you make a mistake in the entry, simply return to the previous character with the left arrow key and reenter the number or letter. After the entry is complete, press the **Enter** key to confirm it. You will follow an example of this type of entry when you enter an Instrument ID name for your 650 in the example below.

To familiarize yourself with the basics of the keypad entry system, follow the instructions below to set the date and time for your 650 and to enter an Instrument ID:

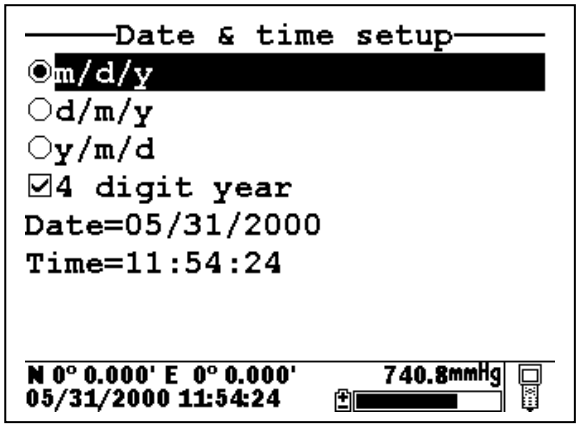
Turn the instrument on to display the **650 Main menu**.



Use the arrow keys to highlight the **System setup** selection and press the **Enter** key. A display similar to the following will appear (Note that the exact format of your displays will depend on the software version):



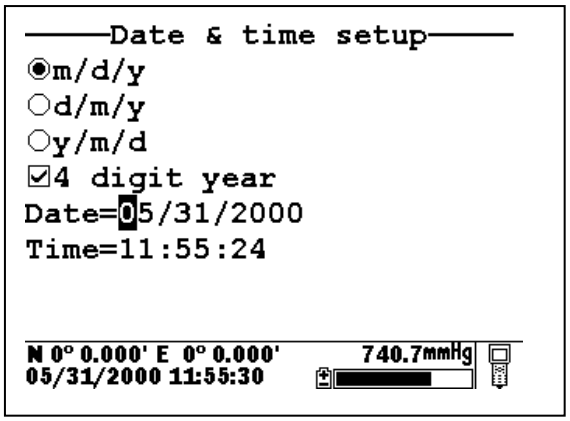
Use the arrow keys to highlight the **Date and Time** selection and press the **Enter** key. The following display will appear:



Highlight the selection for your desired date format and press **Enter** to confirm it.

Highlight the 4-digit year selection and press **Enter** to toggle between 2-digit (no check mark present) and 4-digit (check mark present) options.

Highlight the **Date** selection and press **Enter**. A cursor will appear over the first number in the date as shown in the following display.

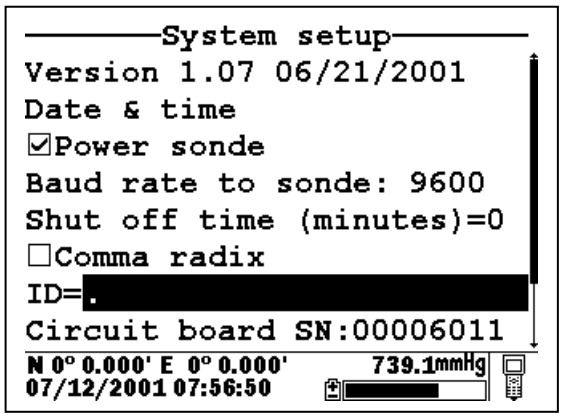


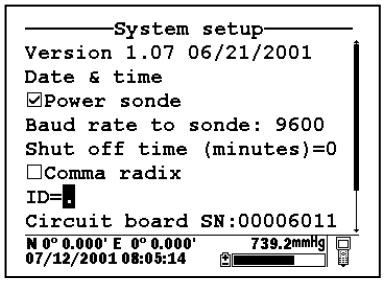
Enter the proper number from the keypad for the first date digit. Note that when you release the key, the cursor moves automatically to the next number. Repeat this process until the date is correct. Then press **Enter** to confirm the Date entry. Note also that, as described above, since alpha characters are inappropriate for this entry, only numeric entry is possible.

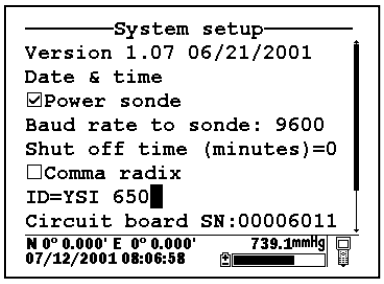
Highlight the **Time** selection and press **Enter**. Repeat the process described above for the **Date** to enter your correct local time using the military format. For example, 2:00 PM must be entered as 14:00.

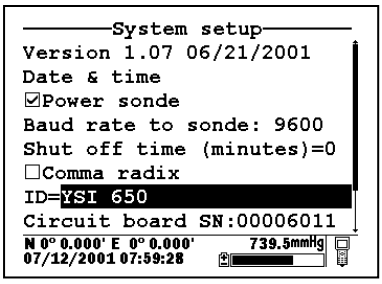
Finally, press the **Escape** key to return to the System setup menu.

Now highlight the **Instrument ID** selection and press **Enter**. The following display will appear.









As shown above, enter the designation "YSI 650" using the general instructions outlined above. Start by pressing the numeric 9 key three times in rapid succession while viewing the characters on the display until a "Y" appears. After the entry is complete, pause and the cursor will automatically move to the next entry position. Now press the numeric 7 four times in succession while viewing the characters on the display. When an "S" appears, pause and the cursor will move automatically to the next entry position. Continue with the entries in this way until ID designation is complete. If you make a mistake, you can use the left arrow key to highlight the flawed entry and correct it. When the entry is complete, press **Enter** to confirm it. Note that for this example, where both alpha and numeric entries are appropriate, the user must press the numeric 2 key 4 times in succession to generate the number 2, as opposed to the previous clock-setting example where a single press of the numeric 2 key generated the number 2.

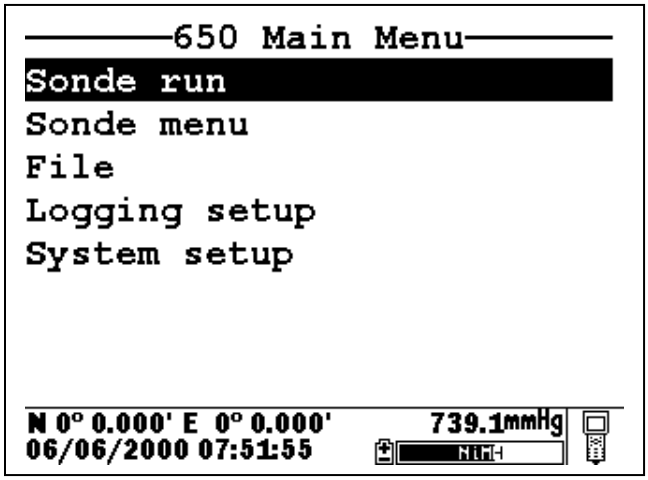
After completing the above example, press the **Escape** key repeatedly to return to the **650 Main menu** and then proceed to the next section.

3.2.9 CONNECTING TO A SONDE

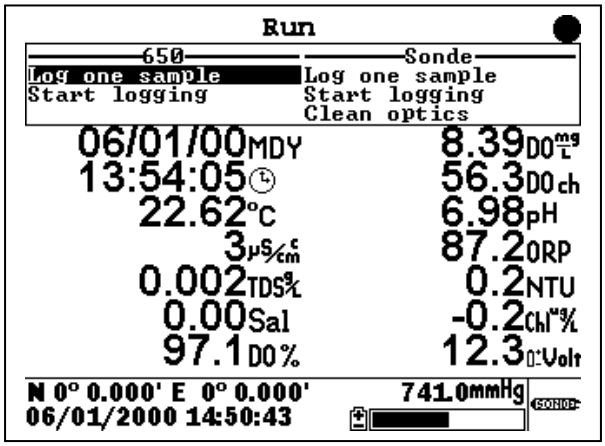
The primary use of the 650 is to interface with YSI 6-series sondes. In this configuration, you will be able to see data from the sonde sensors in real-time on the 650 display as well as to configure the sonde for your particular application. In addition, once sonde interface is established, you will be able to easily log data from the sonde sensors to either the memory of the sonde or the memory of the 650 for later analysis.

The connection between the sonde and the 650 is made via the mating of MS-8 connectors on the standard YSI field cable and the bottom of the 650 case. To make the connection, hold the 650 in one hand, place the 650 and cable connectors together, and rotate the field cable connector until engagement occurs. Then rotate the field cable connector approximately 1-quarter turn until it is fully engaged as evidenced by a

"click". After connecting the sonde to the 650, press the "on" button on the upper left of the 650 keypad to activate the **650 Main menu** as shown below:



Using the arrow keys, highlight the **Sonde run** entry in the Main 650 Menu and press the **Enter** key. Readings from the 6-series sonde sensors will appear on the 650 Main Display in real-time as shown in the following diagram.



The two windows at the top of the display give the capability of logging the displayed readings to either the 650 (top left) or the sonde (top right) memory and allow the user to activate the wiper on turbidity, chlorophyll, and rhodamine WT probes if they are present in the sonde. Instructions for use of these windows are provided in subsequent sections of this manual. Note also that there is a disk with rotating segments in the upper right corner of the display whose movement confirms that the 650/sonde interface is functional.

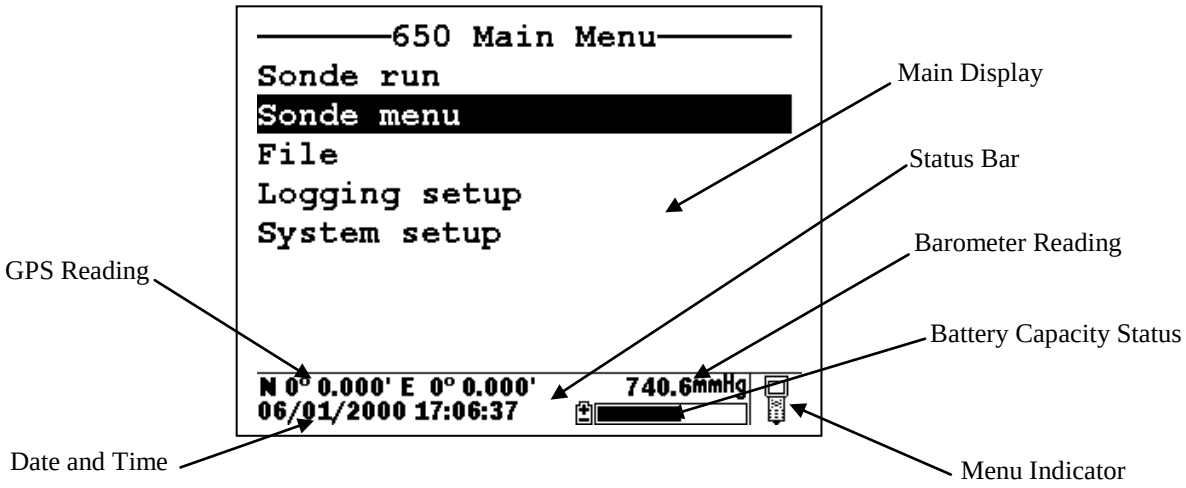
To return to the **650 Main menu**, press the **Escape** key.

CAUTION: When using the 650 MDS in field applications which are in close proximity to communication towers and heavy industrial equipment, or which involve very low humidity conditions, the user may experience problems with logger function. If possible, the user should relocate the sampling site away from these potential sources of interference. In most cases, symptoms will involve instrument shutdown or display lockup. These problems can usually be overcome by either simply pressing the on/off key to reactivate the meter display or by resetting the instrument by removal of battery power as described in

Section 3.11 of this manual. If symptoms persist after these actions, consult YSI Technical Support for advice.

3.2.10 UNDERSTANDING THE STATUS BAR

The diagram below shows the various components of the Status Bar of your 650. Each item identified in the drawing is explained in detail below.



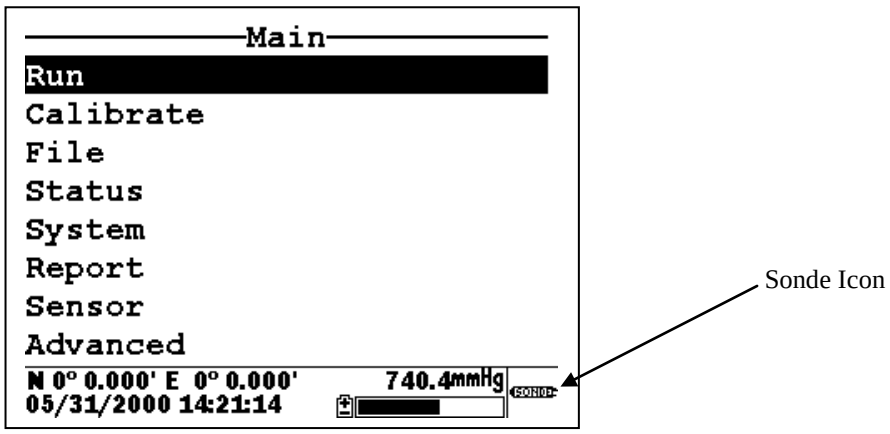
2.10.1 Date and Time. This is the date and time for the clock in the 650, set by the user from the **System setup** menu as described above. The date and time entries are updated in real-time in the Status Bar.

2.10.2 GPS Reading. This value will be present only if a user-supplied GPS unit with NMEA 0183 format is connected to the 650 by the optional YSI 6115 cable. The setup of a GPS interface is described in more detail in Section 3.8 below. Once properly connected to a GPS instrument, the values displayed in the Status Bar are updated in real-time as the system is moved from location to location.

2.10.3 Barometer Reading. This value is the current local barometer reading in units selected by the user in the **System setup** menu. The value is can be used simply as a meteorological parameter or can be used in calibration of sonde dissolved oxygen sensors. The barometer reading is NOT corrected to sea level and is updated in real-time.

2.10.4 Battery Capacity Status. The graphic indicator shows the portion of the battery capacity that is remaining, either for the 4-C cell configuration or for the optional rechargeable battery pack. If a 6117 rechargeable battery pack is in place, a "NiMH" label will appear as part of the indicator. During charging of the battery pack, the black portion of the icon will pulse horizontally until charging is complete. In addition, the entire battery indicator will flash when your batteries are almost exhausted and require replacement (C-cells) or recharge (optional rechargeable battery pack).

2.10.5 Menu Indicator. This icon is located in the lower right portion of the Status Bar and provides a guide as to whether the menu on the display of the 650 originates in the sonde or the 650 itself. The icon shown in the figure above represents a 650 menu; if the menu on the display had originated in the sonde, the Status bar would display a sonde-like icon as shown below.



3.2.11 UPGRADING ECOWATCH FOR WINDOWS SOFTWARE

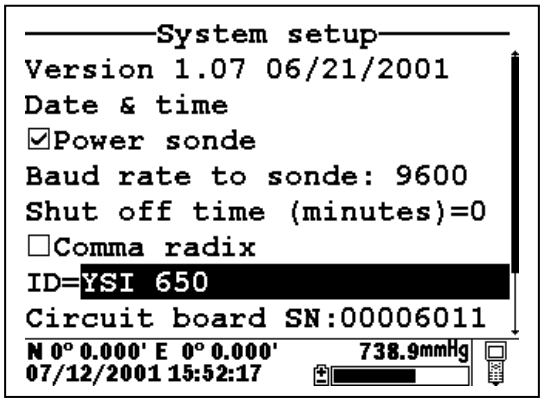
To utilize the full capability of the 650 MDS, you will need to upgrade your version of EcoWatch for Windows from the YSI World Wide Web page (www.ysi.com). Access the YSI Environmental Web Page, select "tech support" from the header, and then "Downloads". After registration, select the EcoWatch for Windows upgrade entry and follow the instructions provided. After the upgrade is complete, your software version (viewed from the EcoWatch toolbar entry **Help|About EcoWatch**) should be 3.13.00 or higher.

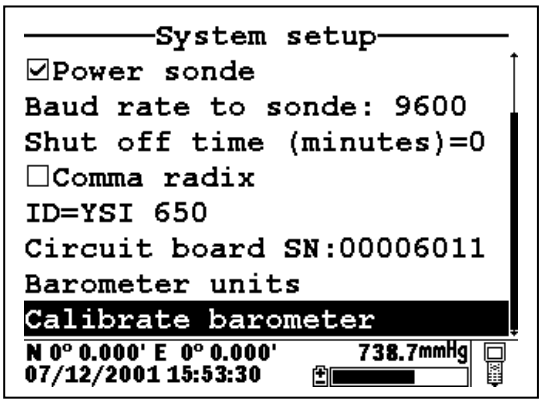
If you encounter difficulties in the upgrade procedures, contact YSI Technical Support for advice.

After reading the above sections and participating in the simple examples provided, you should be familiar with the basics of battery installation, keypad and display function, and keypad data entry. Please proceed to Section 3.3 where the setup of your 650 is described in detail.

3.3 SETTING UP THE 650

The 650 has a number of features which are user-selectable or which can be configured to meet the user's preferences. Most of these choices and selections are found in the **System setup** selection in the Main 650 Menu. To explore the various setup possibilities of the 650, turn the instrument on, select **System setup**, and press **Enter**. The following display will appear. The second display can be observed by scrolling to the bottom of the **System setup** entries with the down arrow.





YSI suggests that the user become familiar with the features provided in the list below prior to using the 650 in field applications. Each item is described in some detail below.

3.3.1 Software version

The software version of your 650 is shown in the first line of the **System setup** menu. As enhancements are introduced to the 650, you will be able to upgrade your 650 from the YSI web page. This item will be used to track those upgrades and will be useful to YSI Technical Support personnel if you have questions about the function of the instrument.

3.3.2 Date and time:

As described above in Section 3.2.8, activate this selection to set the date and time from the 650 keypad.

3.3.3 Power sonde:

If this choice is active, your 6-series sonde will be powered directly from the 650 batteries. The choice MUST be active if you are using a sonde with no internal batteries (600R, 600XL, or 6820). If using a sonde with internal batteries (600XLM, 6920, 600 OMS battery version, or 6600), you can extend the life of your 650 batteries by deactivating this selection. Note that the selection MUST BE OFF in order to determine the voltage of the internal batteries of sondes – important information for Unattended studies.

3.3.4 Baud rate to sonde:

This entry allows the user to adjust the baud rate for communication with the sonde. It does not affect communication for upload of files to a PC. Highlight the entry and press **Enter**. Then select the baud rate of choice and press **Enter** to confirm it. **CAUTION:** The baud rate for the 650 MUST match that in the sonde (usually set at 9600) or communication with the sonde will not be possible. Unless you know that your sonde is set to a baud rate different than 9600, YSI strongly recommends that you leave the baud rate for the 650 set to the default value of 9600.

3.3.5 Shutoff Time:

This value represents the number of minutes until the 650 automatically shuts down to save batteries. Values can be integers from 1 to 15 or enter “0” to disable the shutoff completely.

3.3.6 Comma radix:

The user can toggle between a period (default) and comma for the radix mark by selecting this item and pressing the **Enter** key. If you change your radix mark in the 650, make sure that you also change it to the same symbol in the sonde **Advanced**|**Setup** menu.

3.3.7 ID
Activate this item and **Enter** choice of instrument identification (limit 11 characters) for your 650 as described in Section 3.1.8 above.

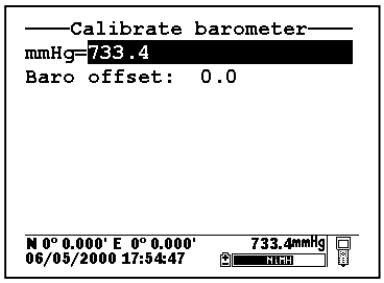
3.3.8 Circuit board SN
This item identifies the serial number of the circuit board resident in your 650. It cannot be changed by the user.

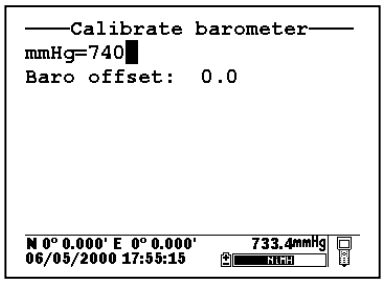
3.3.9 Barometer Units:
Highlighting this selection and pressing **Enter** will activate a display which will allow you to select the units of barometric pressure which will appear in real-time in the display Status Bar. Highlight the desired units and press **Enter** to confirm the selection. This entry will only appear if you have ordered your 650 with the barometer option.

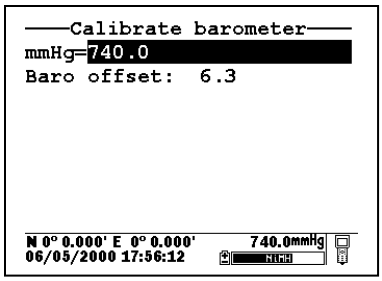
3.3.10 Calibrate Barometer
You may need to scroll down with the arrow keys to view this selection which allows you to calibrate the optional barometer to your local barometric pressure. While the barometer has been factory calibrated and should provide accurate readings on receipt, some sensor drift may occur over time, requiring occasional calibration by the user. Proceed as follows:

Determine your local barometric pressure. This value is usually obtained from an independent laboratory barometer. You can also obtain a barometric pressure value from your local weather service. This latter value has usually been corrected to sea level and therefore must be "uncorrected" before it can be used in calibration of the 650 barometer. See Section 3.9 of this manual for details.

Select **Calibrate barometer** and press **Enter**. Input the known barometric pressure from the 650 keypad in the selected units (mm Hg in the following example) and press **Enter**. Note that in the example, the barometer output has changed from 733.4 (the previous incorrect value) to 740 (the correct value from your laboratory barometer). Note also that a value of the approximate barometer offset which occurred during the calibration (6.3 mm Hg) is present in the display. The offset value is approximate due to the variation in the tenths of a mm digit of the sensor. This value can be used to return the sensor to its factory calibration; simply recalibrate the sensor to a new value which is determined by (current value) – (offset).







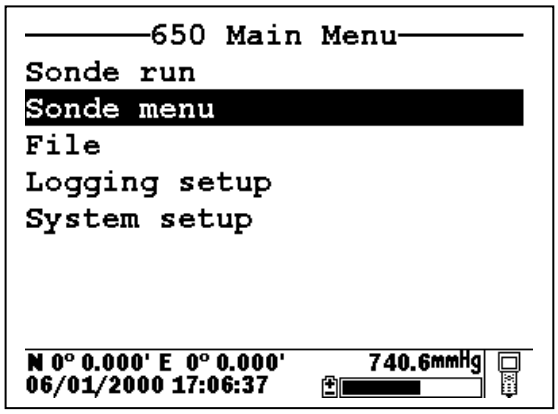
Note that this entry will only appear if your have ordered your 650 with the barometer option.

NOTE: After initial calibration of the barometer, a file with a name defined by the Circuit Board ID and a .glp extension (e.g., 00003245.glp) will automatically be generated and stored in 650 memory. Each additional barometer calibration record for will also be stored. See Section 6.3 below for the transfer of this file to a computer for viewing and storage.

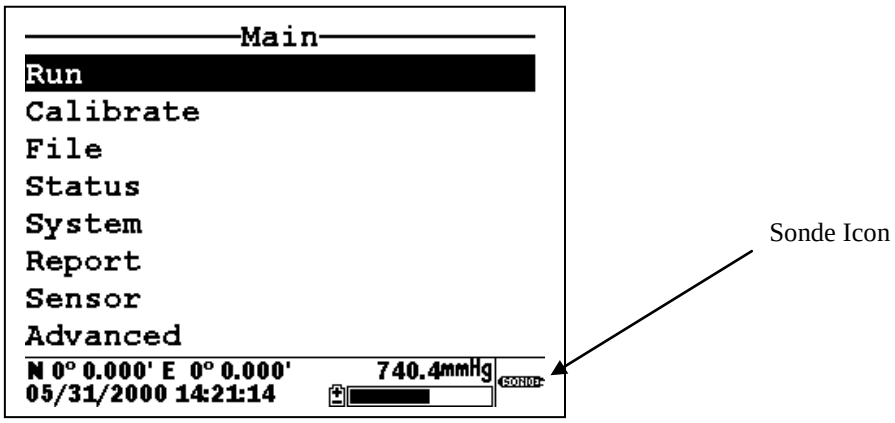
3.4 SONDE MENU INTERFACE

3.4.1 INTRODUCTION

The **Sonde menu** selection in the **650 Main menu** provides a terminal-like interface simulating the connection of the sonde to a PC as described in detail in Section 2 of the 6-series manual. Thus, this item provides access to the entire menu structure of your 6-series sonde software so that you can perform custom setup in the same way that would be possible if the sonde were attached to a PC.



From the **650 Main Menu**, select **Sonde menu** and press **Enter**. A display similar (depending on sonde type and sonde software version) to that shown below will appear:

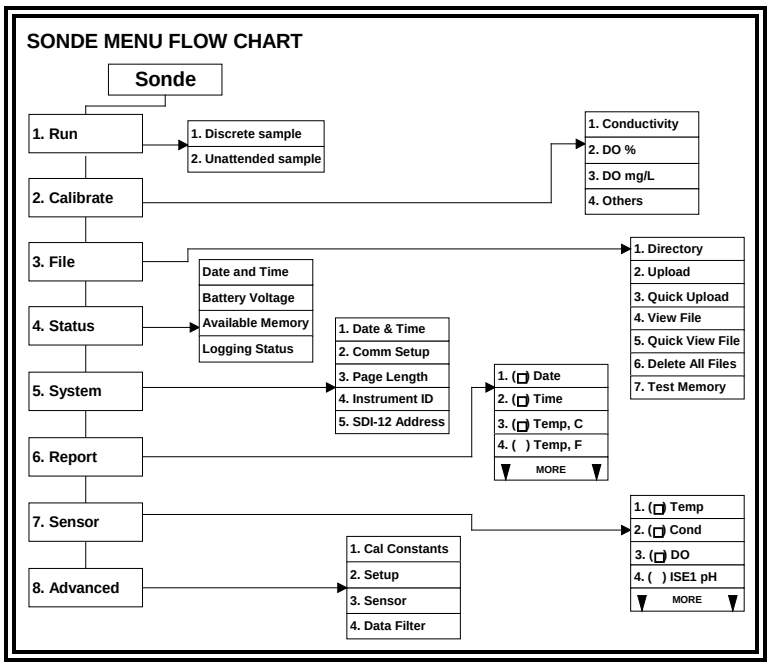


Note that the icon in the lower right of the screen has changed from “meter” to “sonde” indicating that the menu shown originates in the 6-series sonde. Note also that the 650 display has been designed to be very similar to that presented on a monitor when a 6-series sonde is attached to a PC as shown below.

```
------------------Main--------------
---
1-Run                5-System
2-Calibrate          6-Report
3-File               7-Sensor
4-Status             8-Advanced

Select option (0 for previous menu):
```

In fact, the only significant difference between the two interfaces is that, for the PC mode, submenus are accessed by entering the number associated with the specific item, while for the 650 mode the user must use the arrow keys to highlight the item and press the **Enter** key to activate it. Thus, the description of the 6-series sonde menu structure and function which is found in your sonde manual is completely valid as a reference for setting up your sonde for all types of studies. The menu structure of the sonde is presented in diagram form below, followed by two examples in Section 3.4.2 of how to use the **650 Sonde Menu** interface. In addition, brief instructions for frequently performed sonde operation are provided as a reference in Section 3.4.3 below.



NOTE: When using the 650, <u>all</u> sonde functions are accessed through the **Sonde menu** prompt. These include:

- Activating/Deactivating sensors
- Setting up the desired Report output
- Calibrating the sensors
- Changing the sample interval for Discrete Sample studies
- Performing file management functions on the memory in the sonde
- Checking the **Status** or **System setup** of the sonde.
- Setting up sondes for **Unattended sample** deployments.
- Setting up sondes for **Discrete sample** logging studies to sonde memory.
- Uploading files from the sonde memory to the 650.

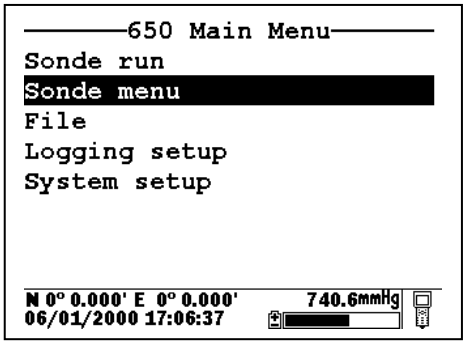
Earlier YSI display/loggers, such as the 610 D and 610 DM, had many of these functions as distinct items in the display menu structure – a significant difference from the 650.

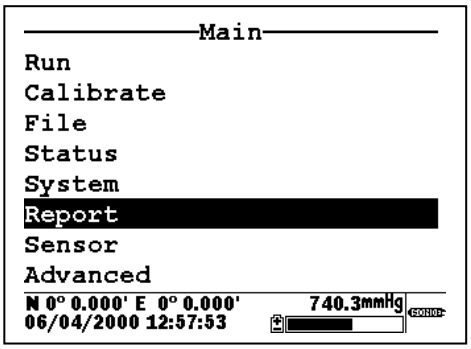
3.4.2 SONDE MENU EXAMPLES

To become familiar with the **650 Sonde menu** function, YSI recommends that the user connect a sonde to their 650 and proceed through the following two examples of common sonde interface operations.

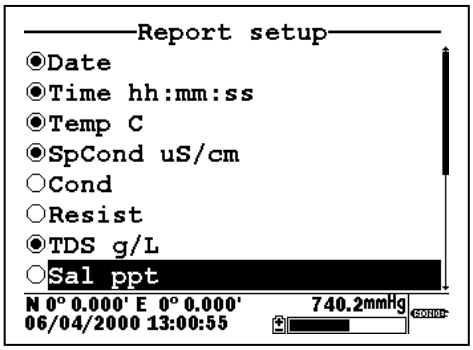
Example 1: Setting up the Report Output – Activation of the Salinity Parameter

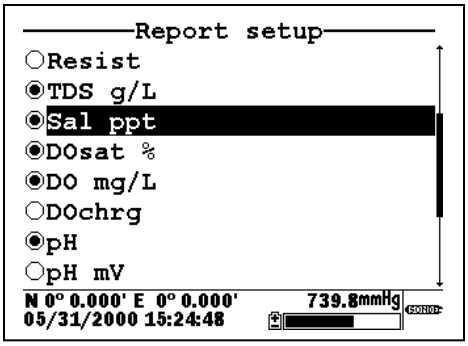
Highlight the **Sonde menu** selection in the 650 Main menu and press **Enter**. Then use the arrow keys highlight the **Report** selection and press **Enter** again.





Use the arrow keys to highlight the **Salinity** selection and then press the **Enter** key to activate the parameter as shown by a dot in the open circle. Note that the entire report list can be accessed by continuing to scroll the highlighting block down with the arrow key. After activation of salinity in the **Report** setup of the sonde, press the **Escape** key twice in succession to return to the **Main sonde** menu.



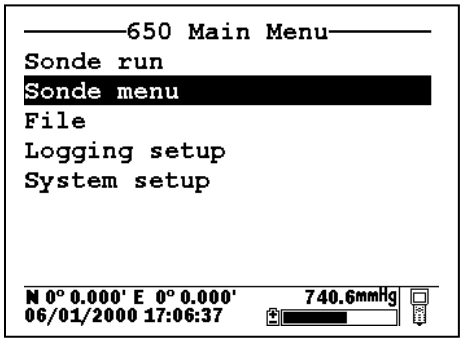


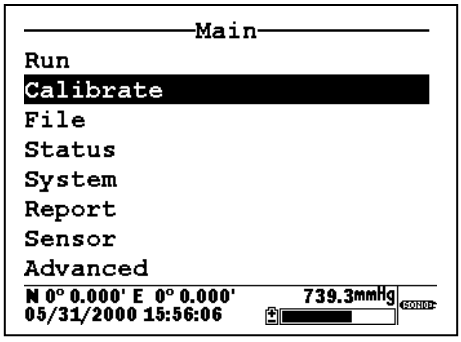
Example 2: Calibrating the Dissolved Oxygen Sensor

NOTE: In the following example, it is assumed that the **Autosleep RS232** function of your sonde has been disabled in the sonde **Advanced|Setup** menu. If **Autosleep** were active, then the display would indicate a countdown of the DO warm-up time and calibrate automatically at the end of this time period. See Section 3.4.9 of this manual and Section 2 of your 6-series manual for more information on the **Autosleep** function.

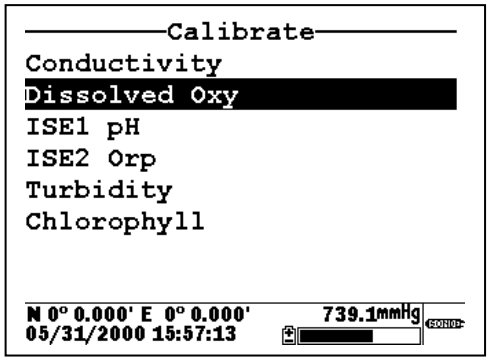
Place the sonde in the calibration chamber with the dissolved oxygen probe in water-saturated air.

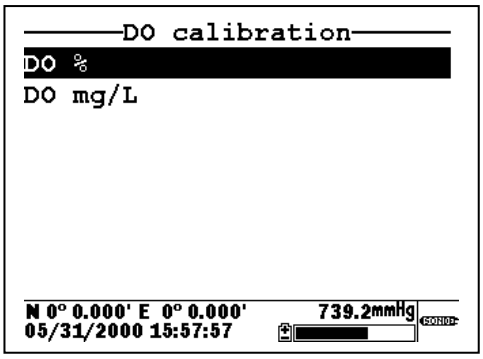
Highlight the **Sonde menu** selection in the 650 Main menu and press **Enter**. Then, use the arrow keys to highlight the **Calibration** selection and press **Enter**.





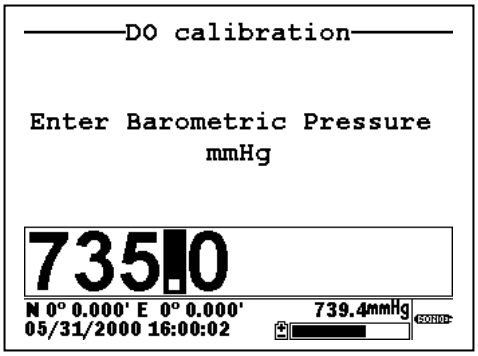
Use the arrow keys to highlight the **Dissolved Oxygen** selection and press **Enter**. Then, Use the arrow keys to highlight the **DO%** selection and press **Enter**.

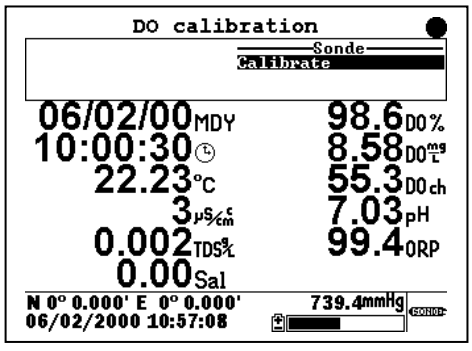




Use the 650 numeric entry keys and the right/left arrow keys to enter the current local barometric pressure. Then, press the **Enter** key and observe the dissolved oxygen reading until stabilization occurs. Make sure the **Calibrate** selection is highlighted in upper window.

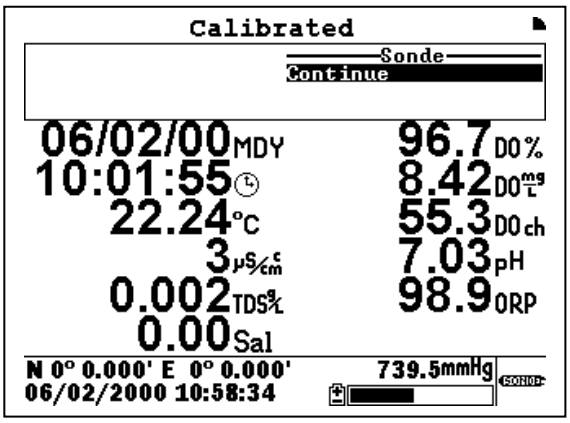
NOTE: The current barometric pressure as read by your 650 will automatically appear as the default value if your 650 is equipped with a barometer.

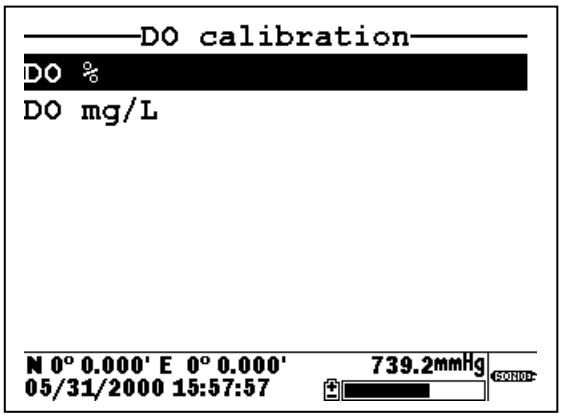




When the dissolved oxygen reading is stable, press the **Enter** key to confirm the calibration as indicated by the message "Calibrated" in the header. In addition, the message in the upper window will change from

"Calibrate" to "Continue". Make sure that "Continue" is highlighted and press **Enter** to return to the **DO calibration** menu.





3.4.3 COMMON OPERATIONS USING THE 650 SONDE MENU SELECTION

The following section provides brief instructions for carrying out frequently used sonde activities via the **Sonde menu** selection of the 650. The instructions do not provide the detail of the examples above, assuming that the user understands how to navigate the menus with the **Enter**, **Escape**, and **Arrow** keys and is able to make alpha/numeric entries from the keypad.

3.4.3.1 Running the sonde in real-time

This function can be accomplished either automatically from the **Sonde run** selection of the 650 menu or by using the **Sonde menu** selection to activate the **Run|Discrete Sample** submenu of the Main 6-series menu. If the **Sonde run** selection is made, data automatically appears on the screen at a sample interval of approximately 1 second. However, if the user chooses to use the **Run** function from the sonde menu, the sample rate can be set to higher values in the Discrete Sample menu. This feature will be described in detail in Section 3.5.2. To **Run** the sonde from the **Discrete sample** menu, highlight **Start sampling** and press the **Enter** key.

3.4.3.2 Setting up a sonde for deployment

Use the **650 Sonde menu** selection to access **Run|Unattended sample** and then proceed with the setup for the monitoring study as described in detail in Section 2 of the 6-series manual. Use the keypad to set the sample interval and input file and site names. Then highlight **Start logging** and press **Enter** to begin the Unattended study in which data is logged directly to the sonde memory. Finally, disconnect the 650 and deploy the sonde.

3.4.3.3 Uploading data from sondes to the 650

Use the **650 Sonde menu** selection to access the sonde **File** menu and then choose either a **Quick upload** (all data in the last file) or **Upload** (complete or partial data in any sonde file) as described in detail in Section 2 of the 6-series manual. After the proper selection is made, press **Enter** and the file will be transferred automatically to the 650 memory with the 650 display indicating that an upload is in progress. The uploading of data files from sondes to the 650 is demonstrated in greater detail in Section 3.7 below.

3.4.3.4 Calibrating sonde sensors

Use the **650 Sonde menu** selection to access the sonde **Calibrate** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for calibration and follow the instructions on the screen. Use the keypad to enter numeric values associated with the calibration standards and press **Enter** to confirm your input. View the data from each calibration standard in real-time and then highlight the **Calibrate** selection in the upper frame. When the output is stable, press **Enter** to confirm the calibration point. Then highlight **Continue** and press **Enter** to either move to the next calibration point or to finalize the calibration. See the example in Section 3.4.2 above for a typical calibration procedure.

NOTE: To return a sensor calibration setup to its factory default setting, access any calibration routine for that particular sensor which asks for numeric input. However, instead of entering numbers, hold the **Enter** key down and press the **Escape** key. Highlight "yes" and press **Enter.** This protocol is the equivalent of entering the command "uncal" from a computer keyboard.

3.4.3.5 Changing the sonde Sensor setup

Use the **650 Sonde menu** selection to access the sonde **Sensor** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for activation/deactivation and press **Enter** to confirm your choice.

3.4.3.6 Changing the sonde Report setup

Use the **650 Sonde menu** selection to access the sonde **Report** menu. Once the menu has been activated, use the arrow keys to highlight a sensor for activation/deactivation and press **Enter** to confirm your choice. See the example in Section 3.4.2 above.

3.4.3.7 Viewing data stored in the sonde

Utilize the **650 Sonde menu** selection to access the **File** menu of the sonde. Highlight the "View file" selection and press **Enter**. Select the file that you want to view. Choose **Proceed** and press **Enter** to view the entire file or select the portion of the data that you want to view and then select **Proceed** and press **Enter** to confirm your selection. After data has appeared on the screen, use the arrow keys to select the particular sensor data that you wish to view.

IMPORTANT: The sonde **Quick view file**, which is designed to show the last page of data of the last logged file when the sonde is interfaced to a PC is slightly different for the sonde/650 interface. Making this selection will indeed show data from the last logged file, but all data (not just the last page) will be displayed. It is still possible, however, to quickly view the last few logged data points which may be important in checking a sonde's current performance in the field. To rapidly move to the end of the file (in either **View file** or **Quick view file**), press and HOLD the down arrow to accelerate the transition to the final data points. Then use the arrow keys to view the data of interest.

3.4.3.8 Configuring and setting the sonde clock

Utilize the **650 Sonde menu** selection to access the **System** menu of the sonde. Highlight the **Date & Time** selection and press **Enter**. Use the arrow keys to highlight the preferred date format and press **Enter** to confirm your selection. Activate/deactivate the **4-digit year** selection, as desired, using the **Enter** key to toggle between choices. Finally, set the date and time by highlighting the entries and inputting new values from the keypad.

3.4.3.9 Setting the sonde Autosleep configuration

As explained in Section 2 of the 6-series manual, the setup of the **Autosleep RS-232** function of the sonde should be governed by the following rules:

- Unattended sample studies/Remote deployments – Autosleep Active
- Discrete sample studies with user present – Autosleep Inactive

The rules are particularly important with regard to the method of dissolved oxygen calibration – automatic at the Unattended sample interval if Autosleep is Active; manually controlled by the user if Autosleep is inactive. See Section 2 of the 6-series manual for additional information on the Autosleep function.

To set the Autosleep function, utilize the 650 **Sonde menu** selection to access the **Advanced|Setup** menu of the sonde. Use the up/down arrow keys to highlight the **Autosleep RS232** selection and toggle the function on/off with the **Enter** key until it is correct for your application.

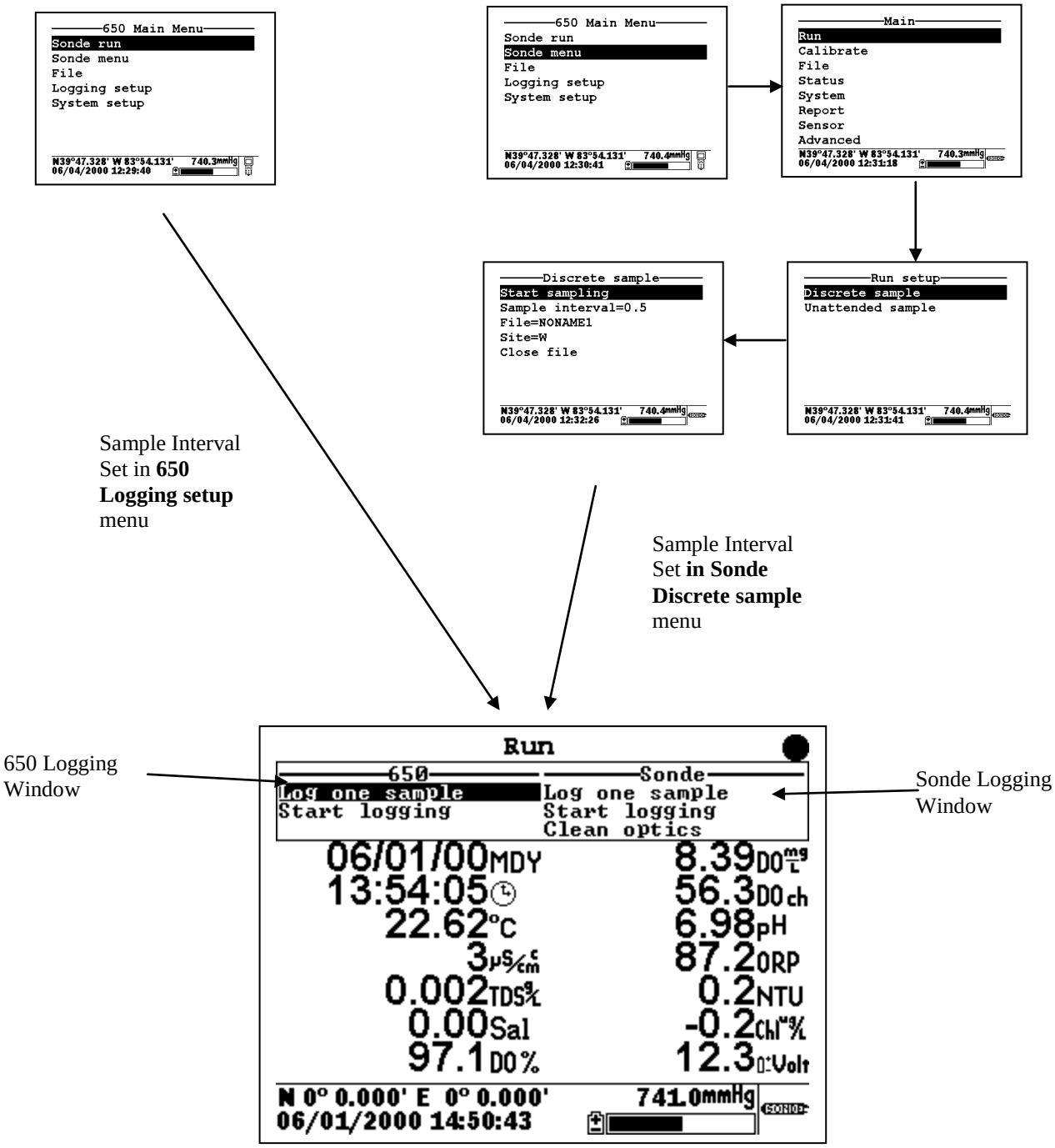
3.5 LOGGING DATA WITH THE 650

3.5.1 INTRODUCTION AND BASICS OF LOGGING

A primary function of the 650 is to facilitate the storage of field data from 6-series sonde sensors for later analysis. It is important to understand that sonde sensor data can be logged to two memory locations using a system consisting of a 650 interfaced with a sonde: (1) memory resident in the sonde and (2) memory resident in the 650 itself. Different applications may favor one logging choice over another. In addition, data can be logged either as single points (after the user has verified stabilization) or as a continuous data stream at a fixed sample interval. No matter where or how the user decides to log field data with a 650/sonde system, the 650 software plays the key role in controlling the process.

When setting up the 650/sonde system for your logging application, it important to realize that the **650 Run** display, from which all logging is initiated can be activated by two methods. The first is to simply highlight the **Sonde run** selection from the 650 menu. The second is to use the **Sonde menu** command from the **650 Main menu** to enter the sonde menu structure and then to activate a **Discrete sample** study. Either of these methods can be used to log data to both the sonde and the 650. However, for most applications, the latter method (Run screen from sonde **Discrete sample**) should be used to activate logging to sonde memory with the sample interval between logged points in a continuous data stream set from the **Discrete sample** menu of the sonde. Likewise, the former method (direct activation of the **650 Run** display from the **Sonde run** command) should usually be used to activate logging to 650 memory with the sample interval set in the Logging setup menu of the 650.

NOTE: Logging to sonde memory may not be possible for some older version 600R, 600XL, and 6820 sondes that were purchased prior to September 1999.



The user should also note the two windows in the upper portion of the display above, one designated "650" and the other "Sonde". All logging, either to sonde or 650 memory is controlled from these windows. As indicated, data storage to the 650 is controlled from the upper left logging window. Storage to the sonde memory is controlled from the upper right logging window. The highlighting cursor associated with the logging windows can be moved within a particular window using the up/down arrows and toggled from window to window using the left/right arrows. Note also that, if your sonde contains an optical sensor, it is possible to activate the probe wiper prior to logging from the Sonde logging window.

While the following sections will show that the logging functions of the 650 have a high degree of flexibility and capability, from a basic point of view, logging with the 650 is simple:

- Decide if you want to log data continuously, and, if so, determine what sample interval between data points is appropriate for you study. If you will be logging to 650 memory, highlight the **Logging setup** selection from the 650 Main menu, then highlight the **Interval** selection and set the interval as desired. If you will be logging to sonde memory, select the **650 Sonde menu** and then **Run|Discrete sample** from the sonde menu. Set the sample interval and then activate the data display by selecting **Start sampling**.

- Select the memory (sonde or 650) in which you want to store your data by toggling between the logging windows.

- Highlight the logging method desired – "Log one sample" for a single logged point or "Start logging" to store a continuous data stream.

- Press **Enter** to activate the logging selection.

- To end the study if a continuous data stream was selected, press **Enter** with the highlight cursor on the **Stop logging** command or press the **Escape** key.

Sections 3.5.2 and 3.5.3 below provide details and real-life examples of logging data to sonde memory and to 650 memory, respectively, using the 650 as the interface.

3.5.2 LOGGING DATA TO SONDE MEMORY

3.5.2.1 INTRODUCTION

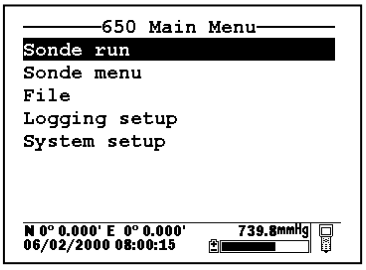
All YSI 6-series sondes sold since September 1999 have memory present on their internal PCBs. In addition, all 600XLM, 6920, and 6600 sondes have internal memory, regardless of the date of purchase. Interface of these sondes to a 650 allows the user to easily store data (either a single point or a continuous stream) to the sonde memory. If a continuous stream of data is desired, the interval between the stored points is controlled by the **Sample interval** in the sonde's **Discrete sample** function. The file name under which this data is stored and the site name associated with the file are also input in the **Discrete sample** function of the sonde using the 650 keypad as the input method. When logging to sonde memory, be sure to follow the instructions above with regard to entering the **650 Run** display either directly from the **650 Sonde run** menu or indirectly from the 650 **Sonde menu** selection to control your sample interval.

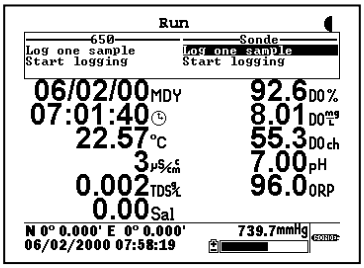
The following examples show the setup and implementation of logging to sonde memory using the 650 as the interface device.

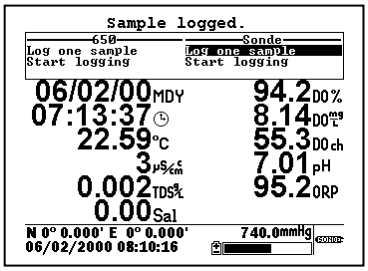
3.5.2.2 EXAMPLE 1 – SIMPLE SINGLE POINT LOGGING TO SONDE MEMORY

A user with a 600XL/650 system wants to store data electronically from a single site rather than writing down the information manually in the field.

To log this data point to the sonde memory, the user highlights the **Sonde run** selection in **the 650 Main menu** and presses **Enter** to begin data display.

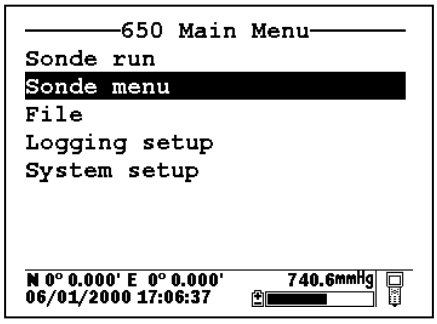


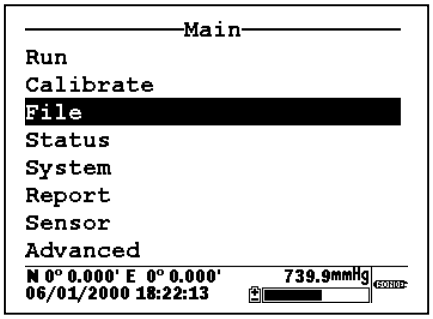




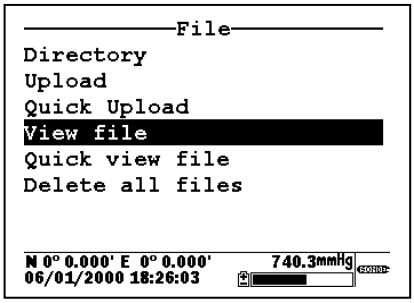
The user places the sonde in the water and watches the readings on the 650 display until they are stable. When stable, the **Log one sample** selection in the Sonde logging window (upper right) is highlighted as shown above and the **Enter** key is pressed. The header changes from "Run" to "Sample logged" to confirm that the data storage to sonde memory was successful and then returns automatically to the **Sonde run** display. The user turns the 650 off and returns to the office to retrieve the data.

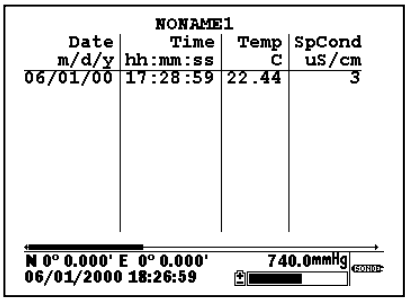
The single data point is stored in the sonde memory under the automatically generated file name NONAME1. The file can be viewed by selecting **Sonde menu** from the 650 Main menu and pressing **Enter**.

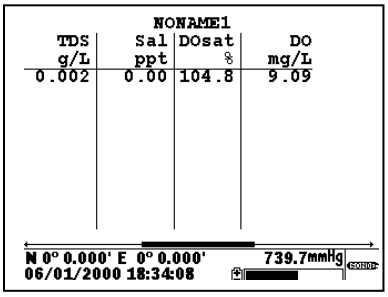




To view the data on return from the site, the user selects the sonde menu **File** selection, presses **Enter** to confirm the entry, and then highlights the**View file** selection and presses **Enter**. Following these instructions generates a display of the data that is stored in the sonde memory under the default name NONAME1. Use the right/left arrow keys to scroll horizontally to view all of the data.







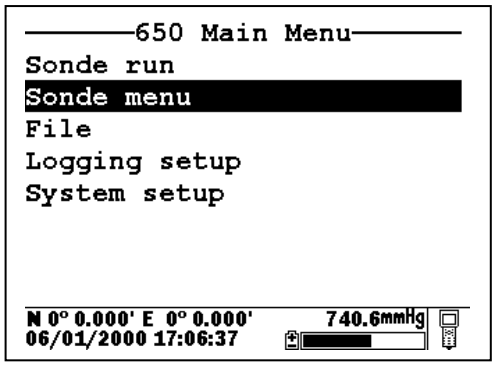
The user manually records the data from the site and turns the system off.

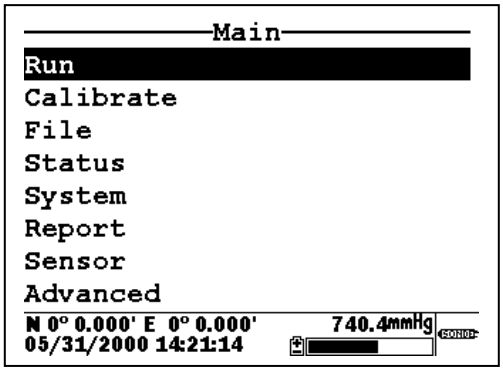
3.5.2.3 EXAMPLE 2 – CONTINUOUS LOGGING APPLICATION TO SONDE MEMORY

A user wants to carry out a vertical profile of a lake from 0 to 30 feet in order to detect the presence of a thermocline, and, if identified, to locate its position in the water column. The experiment will involve lowering a 6920 sonde in 1 foot increments until the bottom of the lake is detected, leaving the sonde at each depth for 3 minutes to allow the sensor readings to stabilize while logging data continuously. Thus, the user will generate data over a 90 minute time period (30 increments times 3 minutes per increment). If data were logged directly to sonde memory at the default 0.5 second sample interval, a very large data file containing 5400 data points would be generated, with little benefit gained from its size.

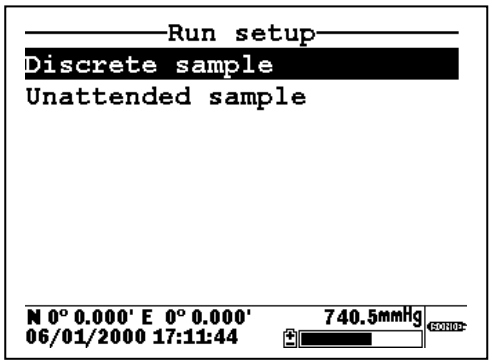
With this in mind, the user decides to increase the sample interval to 16 seconds, thus greatly reducing the amount of data in the file with no loss of real resolution. As explained above, the sample interval for logging to sonde memory is set in the Discrete sample menu of the sonde, and thus the user MUST activate the **650 Run** display indirectly using the **650 Sonde menu** selection as detailed above.

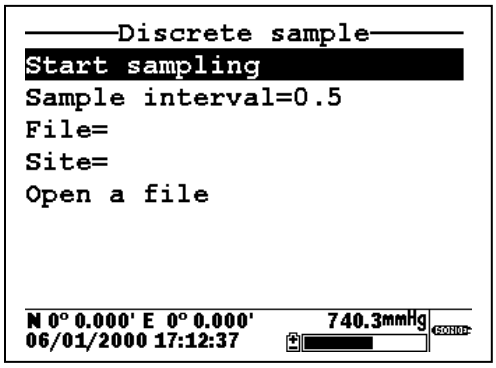
The user attaches the 6920 sonde to a 650. After turning on the 650, the user selects **Sonde menu** from the **650 Main menu** and presses **Enter** to display the **Main** sonde menu.



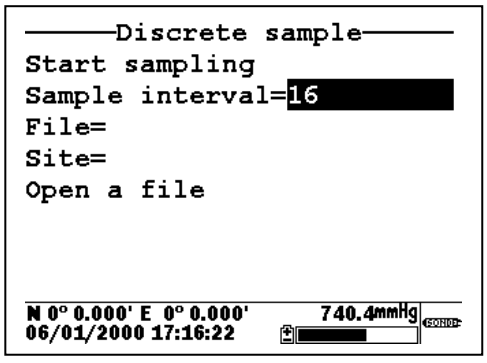


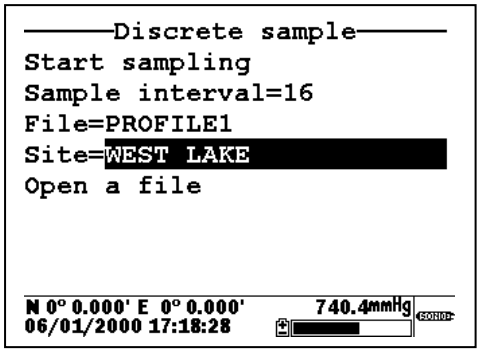
The user then selects **Run** from the sonde Main menu and **Discrete sample** from the **Run** menu, pressing **Enter** to confirm each selection.



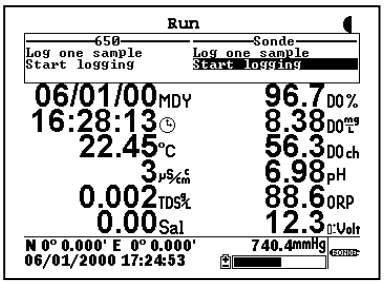


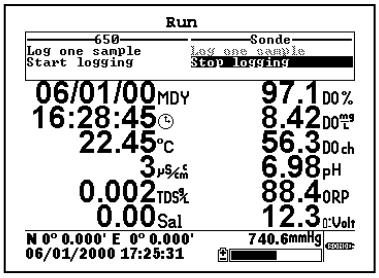
To set up the desired study parameters, the user uses the 650 keypad to change the Sample interval from 0.5 seconds to 16 seconds and inputs custom file (PROFILE1) and site (WEST LAKE) designations.

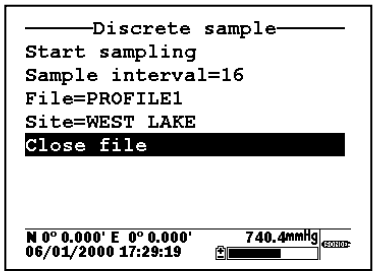




The user then highlights **Start sampling** and lowers the instrument into the water to begin the study. The data displayed on the screen is updated every 16 seconds. The user then highlights the **Start logging** selection in the sonde logging window in the upper right of the display and presses **Enter** to begin logging data to sonde memory. The message in the sonde logging window changes to **Stop logging,** indicating that logging has successfully been activated.

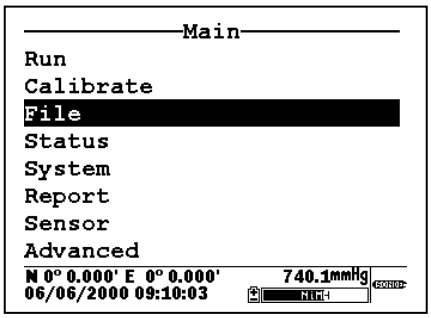


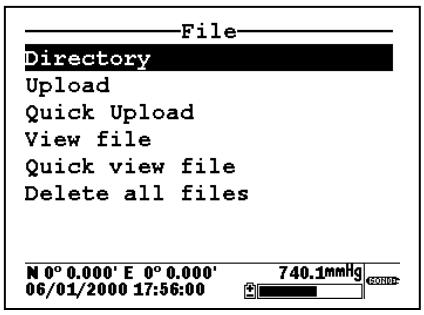




At the end of the 90 minute profile determination, the user either confirms the **Stop logging** command by pressing **Enter** or simply presses the **Escape** key to return to the sonde **Discrete sample** menu, highlights the **Close file** selection, and confirms the file closing by pressing **Enter**.

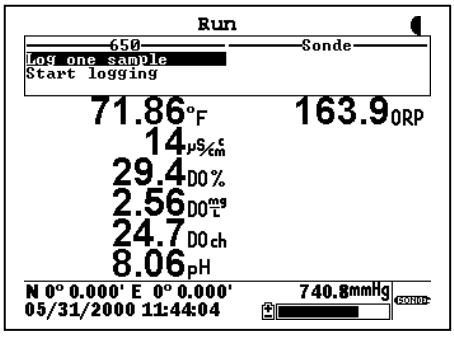
The profile data taken at a 16 second sample interval is now stored in the sonde memory under the file name PROFILE1. It can be viewed on the 650 display and/or uploaded to the 650 memory or directly to a PC by accessing the sonde **File** menu.





3.5.2.4 SONDES WITHOUT MEMORY

If your sonde is a 600R, 600XL, or 6820 purchased prior to September 1999, it may contain a circuit board that does not have memory. With sondes of this type, you will not be able to log data to the sonde – only to the 650 as detailed in the following section. With these no-memory sondes attached to your 650, the **Run** display will show a blank Sonde logging window as shown below.



3.5.3 LOGGING DATA TO 650 MEMORY

3.5.3.1 INTRODUCTION

Even if the sonde in your 650/sonde system has its own memory, it may be more convenient for you to log data directly to the 650 memory simply because you eliminate the need to upload the data after logging, i.e., it will already be resident in 650 memory. In addition, logging directly to 650 memory allows you to log GPS and barometric pressure readings along with sonde sensor data. Barometer and GPS data cannot be logged to sonde memory. Finally, the file/site list capability associated with the 650 is more powerful than that of the sonde, allowing you to log data from several sites to a single file. If these applications are important to you, then it is likely that logging directly to 650 memory should be your first choice. Naturally, if your sonde is a 600R, 600XL, or 6820 with no memory (pre-1999), then you will be REQUIRED to log your sonde data directly to the 650.

Before proceeding in this section, be sure that you review Section 3.5.1 above which describes the basics of logging with a 650 (either to sonde or to 650 memory).

The following sections will provide details and examples of the flexibility of logging sonde data to 650 memory. The distinction between (a) simple occasional logging with file and site names entered at the logging site and (b) logging to a more sophisticated file structure where file parameters are entered into a site list prior to going to the field will be described.

3.5.3.2 SIMPLE LOGGING TO 650 MEMORY

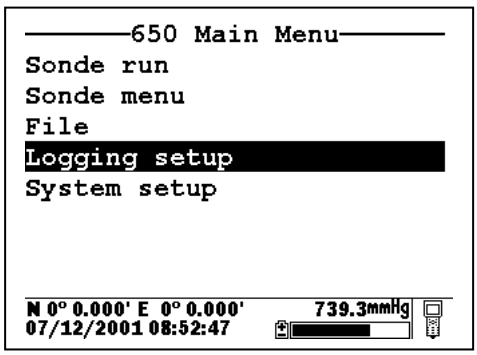
The term “simple logging” to 650 memory refers to the method of defining file and site names for the study. In applications of this type, the user inputs new file and site (optional) names for each study at the time the data is logged.

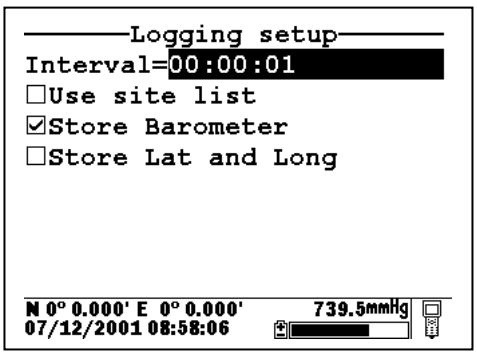
IMPORTANT: The **Use site list** selection in the **650 Logging setup** menu should be INACTIVE for the example below which demonstrates simple logging.

A user with a 600XL/650 system wants to store a continuous stream of data electronically for a single site at a sample interval of 10 seconds between data points. Note that this is a similar example to that in 3.5.2.2 above, except that the logging is to 650, rather than sonde, memory and a data stream, rather than a single point, will be logged.

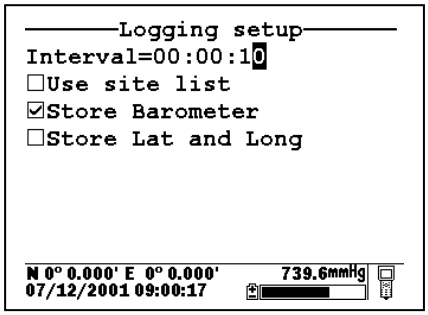
The first step in this application is to make certain that the sample interval is set correctly for the logging study. The factory default sample interval of 1 second will therefore need to be changed to 10 seconds.

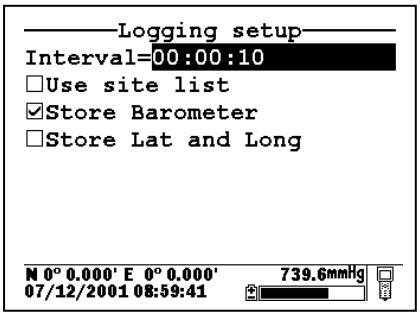
To set the sample interval, highlight the **Logging setup** entry in the **650 Main menu** and press Enter.



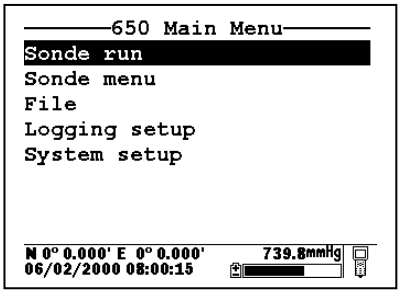


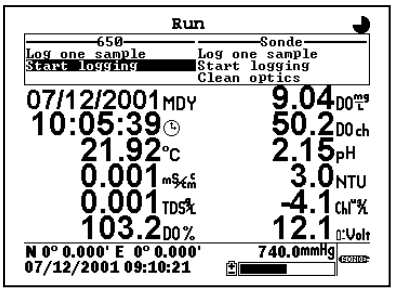
Press Enter at the highlighted **Interval** selection and use the arrow keys to scroll to the right and change the interval from 1 second to 10 seconds. Confirm the selection by pressing **Enter** and then press **Esc** to return to the **650 Main menu**.



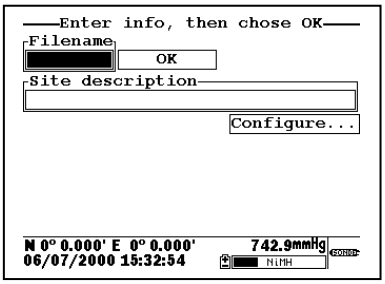


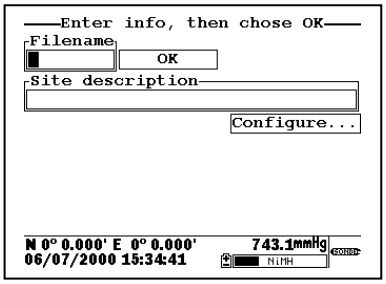
Once the sample interval is set correctly in the **650 Logging setup** menu, the user simply highlights the **Sonde run** selection in the **650 Main menu** and presses **Enter** to begin data display.

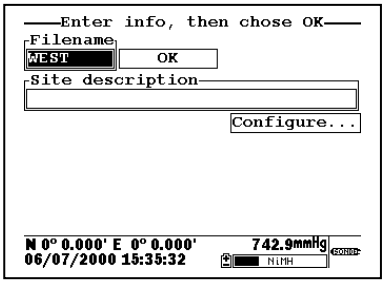


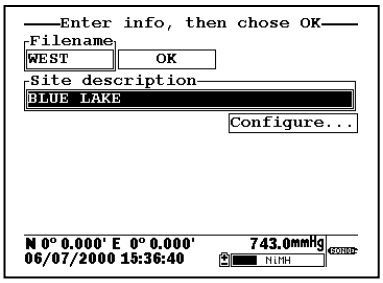


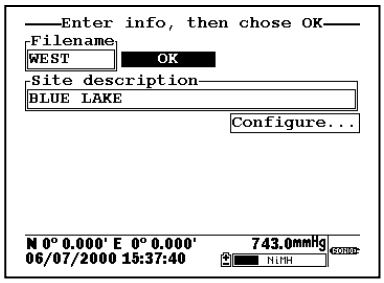
The user places the sonde in the water and then highlights the **Start logging** selection in the 650 logging window (upper left) and presses **Enter**. The user is then prompted to enter a **Filename and Site description** for the study as shown below.

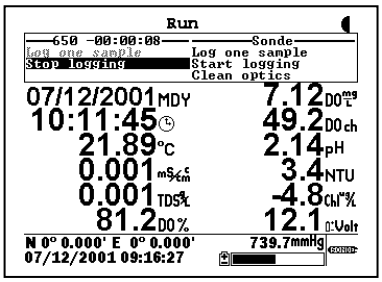








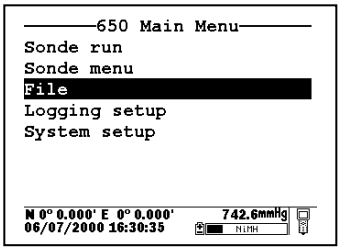


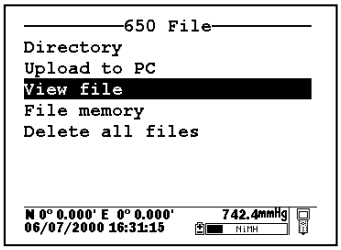


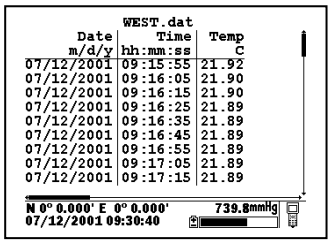
Using the arrow keys, the **Filename** window is highlighted, the user presses the **Enter** key and then inputs the file name (in this case, WEST) from the keypad as shown above. A site name (BLUE LAKE) is then entered from the keypad by highlighting the **Site description** window and proceeding as for the **File** name. Pressing **Enter** confirms the **Site** entry. The user then highlights the **OK** window and presses **Enter** to log the point. The header of the 650 logging windows changes to **Stop logging** to confirm that the data storage to 650 memory is active and a countdown timer appears at the top of the display to show the exact moment a point is logged to 650 memory. When the study is complete, the user highlights the **Stop logging** selection and presses **Enter** to terminate logging.

NOTE: For ultimate simplicity, it was not necessary to enter either a file or a site name in the above application. If the **OK** window had been highlighted immediately and **Enter** pressed, a point will be logged to a file in the 650 memory under the designation NONAME1. It is also possible to input a custom file name, but not enter a site name and then log the point.

The stream of data is stored in the 650 memory under the file name WEST that was input by the user. The file can be viewed by selecting **File** from the 650 Main menu and pressing **Enter**. Then highlight the **View file** selection and then the selected file (WEST), pressing **Enter** after each entry. The data in the file will be displayed as shown below. Use the arrow keys to scroll horizontally in order to view all of the data.

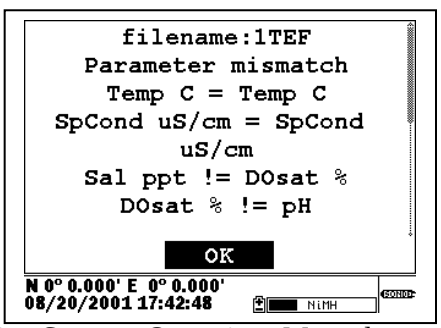






Note that, using these same basic guidelines, data could have been logged at another site on the same day with the user inputting a different site designation (file name and site name) in the field. Data could also have been logged single points or as a continuous data stream at each site simply by the choice of **Log single point** or **Start logging,** respectively, in the 650 Logging window.

Data can also be appended at later times to existing site designations. However, there is a limitation on this process**: the parameter setup during subsequent logging runs MUST be exactly the same as for the first entry.** For example, if you add a sonde parameter to the Report for the second logging run to a particular site, you will not be able to append this data to the existing file. If you logged Barometer or GPS readings to the initial file you will be required to maintain the logging of these files on subsequent logging runs. If your current parameter setup is different from the one used initially, a "Parameter Mismatch" screen similar to that shown below will appear when you try to log data to the old site designation. The screen should help in pinpointing the change in your parameter setup that is causing the inability to append the file. In the example below, the old parameter setup is shown on the right of the screen and the new parameter setup is on the left. It is evident that the mismatch occurs in the third line where salinity from the new setup is "mismatched" with "DO %" from the old setup. The screen thus shows that salinity has been added to the parameter list between the two logging studies and must be removed if the original file is to be appended with further data.



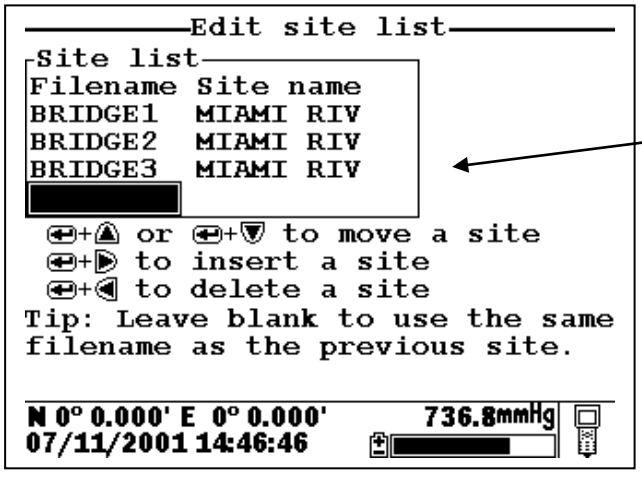
3.5.3.3 LOGGING TO 650 MEMORY WITH A SITE LIST

In the example above, you learned how to log data to 650 memory that had file and site designations input to the logger at the time that the data was logged in the field. It is also possible, and in most cases more convenient, to place file and site designations into the 650 memory in the office or laboratory before moving to field for logging studies. This is particularly true if you are aware of the sites at which you will be determining water quality data and/or which you will be visiting on a regular basis. The following section describes how to set up site lists which contain entries designated "Site Designations" that will be instantly available to the user in the field to facilitate the logging of data in the field with pre-established naming of files and sites. There are two kinds of **Site Designations** available for use in Site lists:

- **Site Designations** associated with applications where data from a single site is always logged to a single file. This type is referred to as a "Single-Site Designation" and is characterized by two parameters – a file name and a site name. Files logged to 650 memory under a **Single-Site Designations** will be characterized primarily by the file name, but will also have the Site name attached, so that it is viewable in either the **650 File directory** or in EcoWatch for Windows after upload to a PC

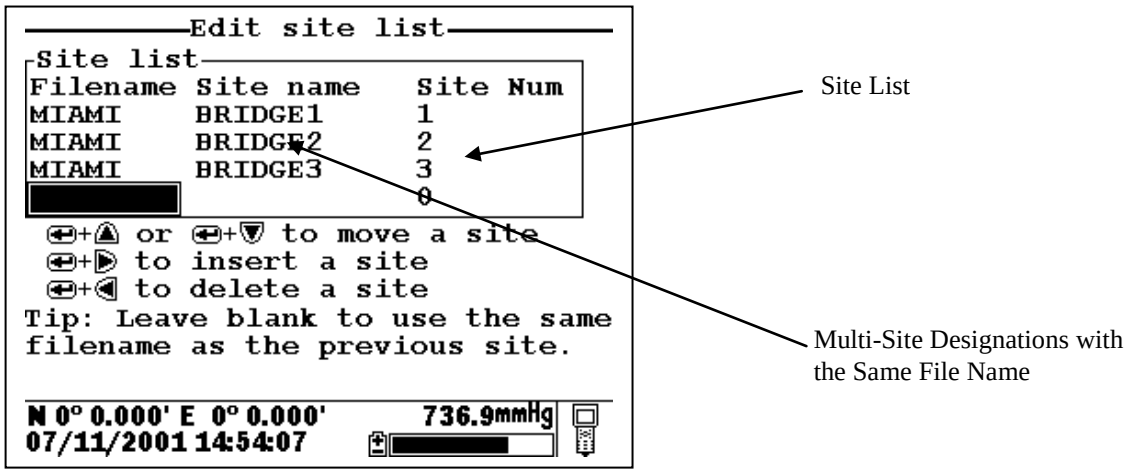
- **Site Designations** associated with applications where data from multiple sites are logged to a single file. This type is referred to as a "Multi-site Designation" and is characterized by three parameters – a file name, a site name, and a site number. Files logged to 650 memory under **Multi-site Designations** are characterized by a file name, but not a site name, since multiple sites are involved. However, each data point has a Site Number attached to it so that the user can easily determine the sampling site when viewing the data from the **650 File** menu or processing the data in EcoWatch for Windows after upload to a PC.

When reading the following section on the use of the **650 Site list**, remember that a **Site List** is a compilation of individual entries called **Site Designations**. **Single-Site Designations** are used when the data from a particular location is always logged to the same single file. **A Single-Site Designation** is characterized by a unique file name. **Multi-Site Designations** are used when data from several locations are logged to a single file. For **Multi-site Designations**, there will a single **File Name** with multiple **Site Names** and **Site Numbers**. The following displays show examples of **Single** and **Multi-Site Designations**.



Site List

Single-Site Designations with Different File Names



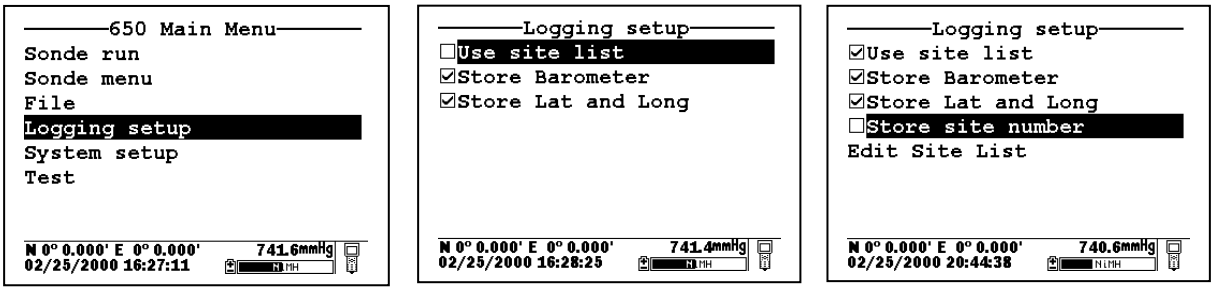
Note that Site lists containing Single Site Designations are usually input with the designation Store Site Number INACTIVE in the **650 Logging setup** menu. Thus, no site numbers appear in the first **Site list** example. Conversely, **Site lists** containing **Multi-Site Designations** MUST be input with the **Store Site Number** selection ACTIVE as shown in the second example.

As noted above, establishment of either of these two types of **Site Designations** that are stored in 650 memory in a **Site List** will allow you to log field data to the 650 memory without entering file/site information from the 650 keypad in the field at each site. You will easily be able to access previously entered **Site Designation** information from this the **Site List** at each field site and thus simplify your record keeping and logging procedures. To utilize the full capability of the 650 logging system, you will need to understand how to set up and use these two types of **Site Designations**, particularly if you are performing multiple or replicate logging studies at various field sites. The following discussion and examples should help you understand how to set up site lists for various applications.

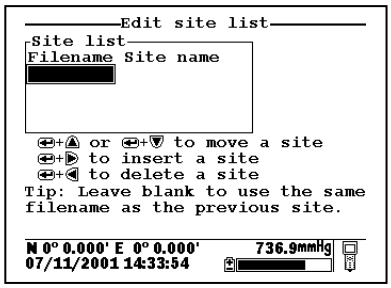
LOGGING OF DATA TO 650 MEMORY FROM SINGLE SITES TO SINGLE FILES – USE OF SINGLE-SITE DESIGNATIONS IN A SITE LIST

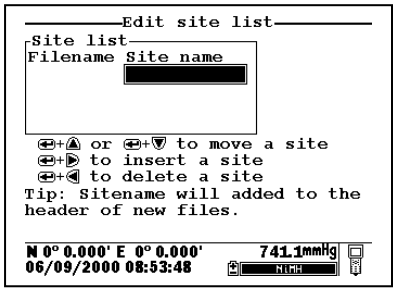
The setup and use of **Single-Site Designations** will be provided in the following application example: Water quality data needs to be collected for two sites at the West and East ends of a lake (Blue Lake) at various time intervals for 30 days. The environmental scientists want all of the data for each site to be in a separate data file that can be reported from EcoWatch for Windows or from a spreadsheet. The key to this application is that each physical location will need to be characterized by a different **File Name** in the **Site Designation**.

To establish a site list in the 650 memory for this application, highlight the **Logging setup** selection in the 650 Main menu and press **Enter**. The following screen will appear. Make certain that the selection **Use Site list** is active to display the full capability of the Logging setup as shown below. To set up a list with Single-Site Designations the selection **Store Site number** should be INACTIVE (as shown below) before proceeding.



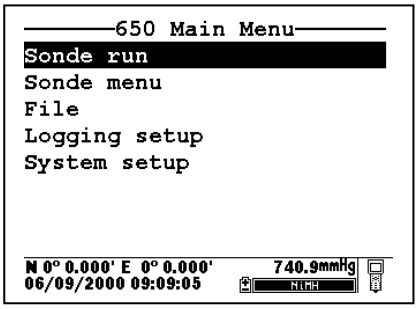
Note also that if you have purchased a 650 without the barometer option, the selection **Store barometer** will not be present. Decide whether or not you want to store GPS and barometer information with your data file and activate/deactivate the **Store Lat and Long** and **Store Barometer** selections appropriately. Leaving these selections active will occupy memory in the 650 during logging and this factor may be a consideration if you have purchased a 650 with "Low" memory and you do not really require this information in your file. Once these selections have been made, highlight the **Edit site list** selection and press **Enter** to display the screen below. Note that you can use the left/right arrows to scroll between the **Filename** and **Site name** selections and that tips about the meaning of these terms is provided at the bottom of the display depending on the position of the cursor.

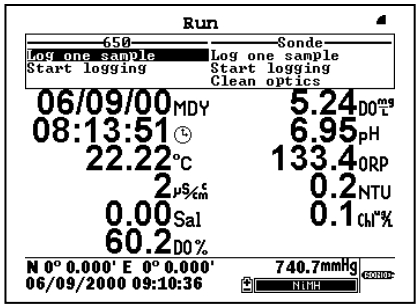




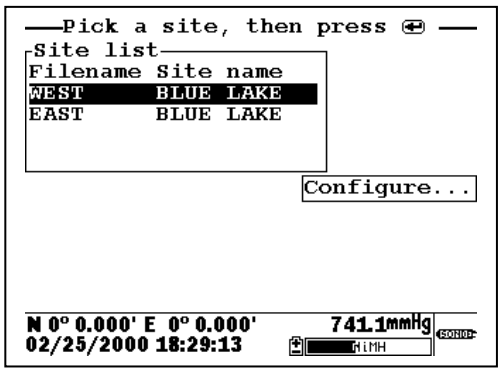
To make **Site list** entries for this application, begin by highlighting the **Filename** position, pressing **Enter** and inputting the file name (WEST, in this case) from the keypad. Press **Enter** to confirm the entry and the cursor will automatically move to the right for the entry of a **Site name**. Enter BLUE LAKE for the site and press **Enter** to confirm the entry. The cursor will move automatically to the next **Filename** entry position. Now enter EAST for the file name and BLUE LAKE for the site name, pressing **Enter** after each entry to confirm. Your site list should appear like that in the following display.

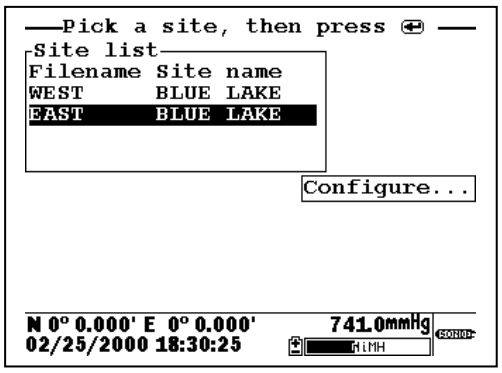
You have now established a site list that will be available in the field for logging of data to two files on BLUE LAKE -- EAST and WEST. To use this list, you need to first make certain that the entry **Use site list** is active in the **650 logging setup**. Then travel to the first location, identified by the **Filename** WEST, activate the **650 Run** display, and then select either a continuous data stream (**Start logging**) or a single data entry (**Log single point**) from the 650 logging window.





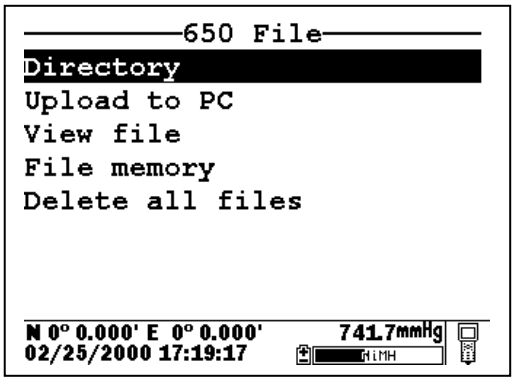
Then press **Enter.** When the logging prompt is activated, the site list will automatically appear on the display and be available for use in your study as shown below. First highlight the WEST file (since you are at that location) and press **Enter** to log data to the 650 memory. An indication that the logging was successful will appear in the 650 logging window. Then move to the next location (EAST), activate the 650 logging function, and repeat the logging process, but this time highlighting the EAST Filename entry.

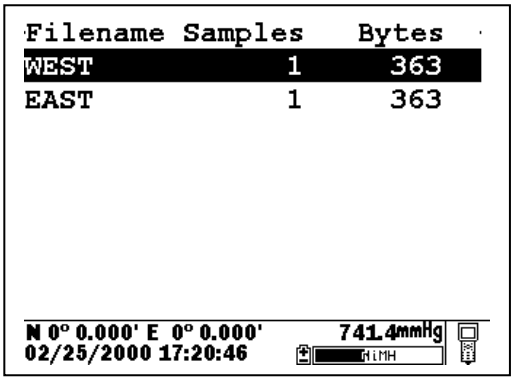




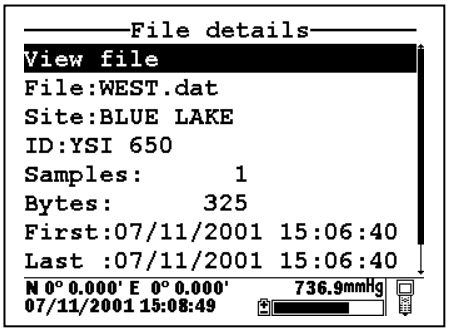
NOTE: If you want to return to the **Edit site list** display for changes before logging, use the RIGHT ARROW KEY to highlight the **Configure** selection and press **Enter**. The up/down arrows will only scroll within the Site list.

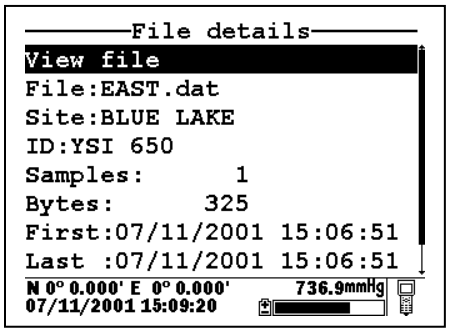
The data from the two locations has been logged to the selected files that can be either viewed manually using the 650 **View file** menu or uploaded to EcoWatch for Windows from the **650 File** menu. This means that all data for the West and East sites are located in <u>separate</u> files identified by the **Filenames** WEST and EAST as shown in the 650 File Directory below.





Details of the files (shown by pressing **Enter** when the File is highlighted in **Directory**) are shown below. Note that the site name (BLUE LAKE) is listed in the file since the data was logged using **Single-Site Designations**.





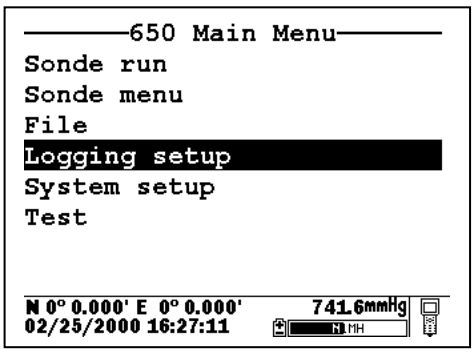
These files will remain "open" in 650 memory so that you can return to each location at a future time and log more data to the file designations WEST and EAST (but see note below). The key for this **Site list** setup is that all data logged will be stored in a separate file for each location (WEST and EAST) which were designated as file names at the site BLUE LAKE.

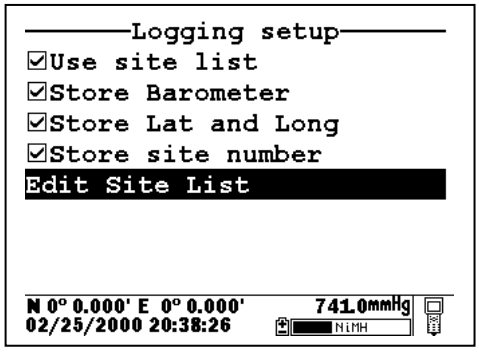
NOTE CAREFULLY: As described above for non-site list files, there is a limitation on appending data to existing files: the parameter setup during subsequent logging runs MUST be exactly the same as for the first entry. For example, if you add a sonde parameter to the Report for the second logging run to a particular site, you will not be able to append this data to the existing file. If you logged Barometer or GPS readings to the initial file you will be required to maintain the logging of these files on subsequent logging runs. If your current parameter setup is different from the one used initially, the **Site Designation** for that file will be "grayed-out" in the **Site list** and will not be available until you adjust your parameter setup. If you try to log data to the grayed-out file, you will be shown a "Parameter Mismatch" screen similar to that for non-site list files which will aid in diagnosing the differences in the parameter setup that is preventing the existing file from being appended with new data

LOGGING OF DATA FROM SEVERAL DIFFERENT SITES TO THE SAME FILE – USE OF A "MULTI-SITE" LIST

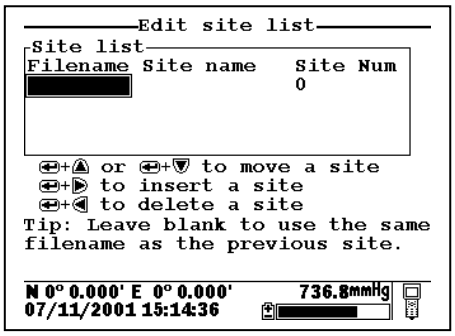
The setup and use of **Multi-Site Designations** will be provided in the following example which deals with a different approach to the application in the previous example on **Single-Site Designations**: Water quality data needs to be collected for two sites at the West and East ends of a lake (Blue Lake) at various time intervals for 30 days. In this case, the environmental scientists want all of the data in a single file for recording keeping convenience. The key to this application is that the **Site list** will need to contain **Multi-Site Designations** with the same **Filename,** but with different **Site names and Site numbers** to characterize each physical location.

To make Site list entries for this application, highlight the **Logging setup** selection in the 650 main menu and press **Enter**. The following screen will appear. As in the previous **Site list** setup, make certain that you have activated/deactivated the **Store barometer** and **Store Lat and Long** settings as appropriate for your application. The real key, however, in configuring the **Logging setup** display for use with a Multi-site list is that you MUST make certain that the selection **Store Site number** is ACTIVE (as shown below) before proceeding.

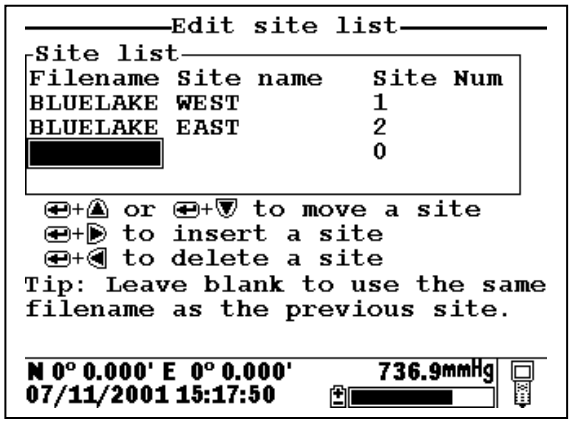




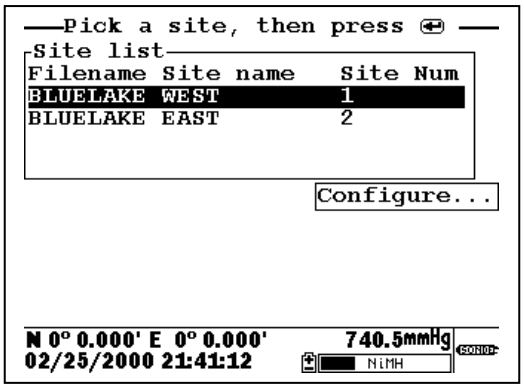
Then highlight the **Edit site list** selection and press **Enter** to display the following screen.

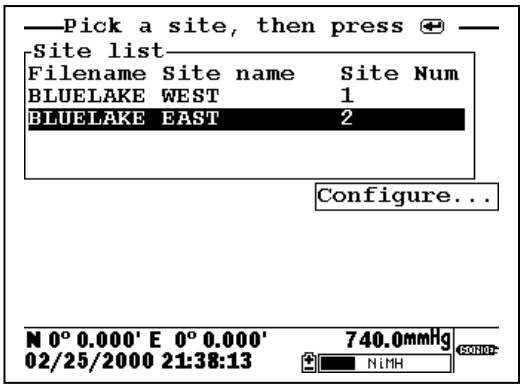


To generate a list of **Multi-Site Designations** for storing readings from various sites to the same file, establish two entries in the site list with the same file name (BLUELAKE). The entries will be differentiated by different **Site names** (WEST and EAST), and, more importantly, by different **Site Numbers** (1 for WEST and 2 for EAST) so that your site list appears as shown in display below.



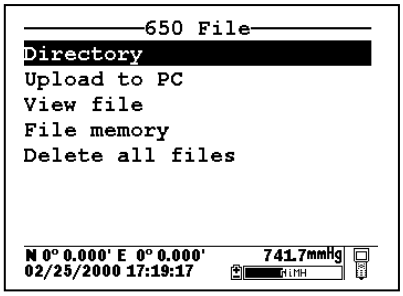
You have now established a site list that will be available in the field for logging of data from two sites (WEST and EAST) to a single file (BLUELAKE). To use this list, you need to first make certain that the entry **Use site list** is active in the **650 logging** setup. Then travel to the WEST site, activate the 650 **Run** display and then select either a continuous data stream (**Start** logging) or a single data entry (**Log single point**) from the 650 logging window, and press **Enter** When the logging prompt is activated, the site list will automatically appear on the display and be available for use in your study as shown below. First highlight the entry with the WEST **Site name** (since your are at that location) and press **Enter** to log data to the 650 memory. An indication that the logging was successful will appear in the 650 logging window. Then move to the next location (EAST), activate the 650 logging function, and repeat the logging process, but this time highlighting the EAST **Site name** entry.

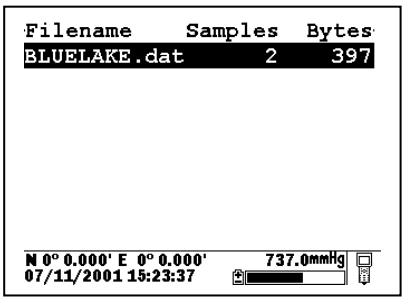


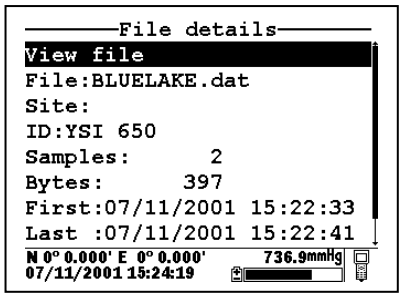


NOTE: If you want to return to the **Edit site list** display for changes before logging, use the RIGHT ARROW KEY to highlight the **Configure** selection and press **Enter**. The up/down arrows will only scroll within the **Site list**.

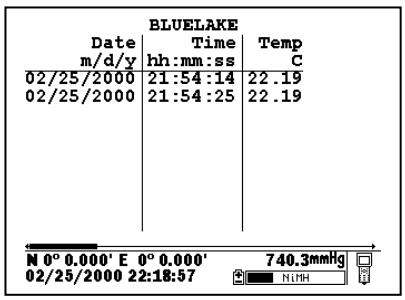
The data for two different sites has now been logged to the single file (BLUELAKE) that can be either viewed manually using the **650 View file** menu or uploaded to EcoWatch for Windows from **the 650 File|Upload to PC** menu. The Site Number ("1" for the WEST site and "2" for the EAST site) will be stored with each data point and will be thus be available for identifying where the data was taken. The file BLUELAKE can be examined by use of the 650 **File** selection. In the 650 **File** menu, highlight **Directory** and press **Enter** as shown below. Then press **Enter** with the cursor on the BLUELAKE file to show the file details.

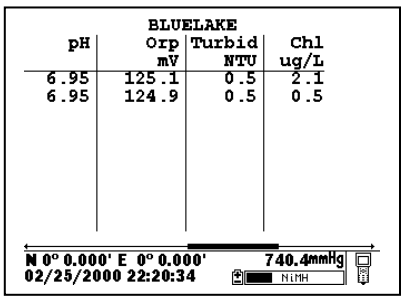


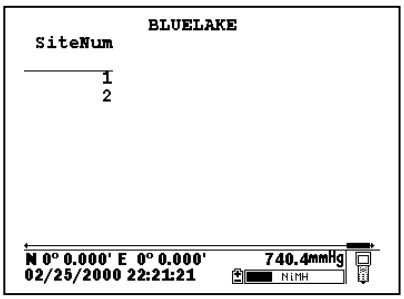




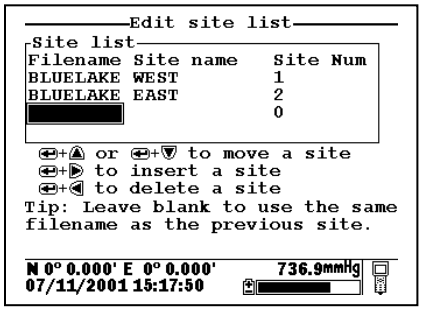
Note that there is NO Site name listed for the file BLUELAKE since data from more than on site was logged to it. Now highlight the **View file selection** and press **Enter** to display the data in BLUELAKE as shown below.







Note that the data from two sites is identified by the **Site Number** attached to each data record. To index these numbers to the appropriate locations, the user must consult the **Site list** by activating **Edit site list** from the **650 Logging setup** menu. The correlation between site names and numbers is found here, indicating that Site 1 is WEST and Site 2 is EAST.

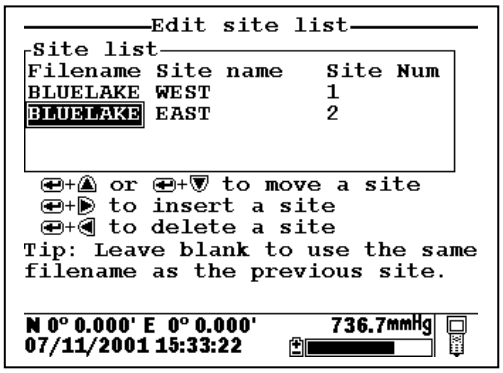


This file will remain in 650 memory so that you can return to each location at a future time and log more data to the **Site designations** WEST and EAST. The key for this site list setup is that all data logged will be stored in the same file (BLUELAKE) under different **Site Numbers** for each location (1 for WEST and 2 for EAST).

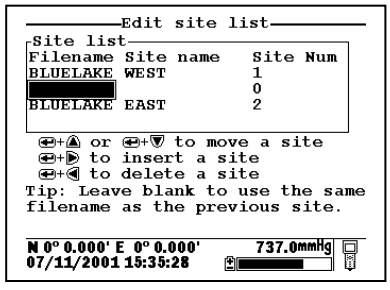
NOTE CAREFULLY: The same limitation noted above applies for appending the file BLUELAKE with additional data from these or other sites – the logging setup (sonde parameters, barometer, GPS) must be identical to that for the initially-stored data. If there has been a change in setup, the **Site Designation** will be "grayed-out" in the **Site List** indicating a parameter mismatch.

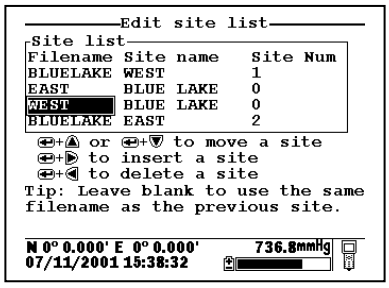
3.5.3.4 EDITING YOUR SITE LIST

The 650 software provides powerful tools for editing your site list. Actions such as inserting (adding) new entries, deleting existing entries, and moving entries within the list can be carried out easily from the keypad**.** Highlight the **Edit site list** entry in the **650 Logging setup** display and press **Enter** to show the following screen.

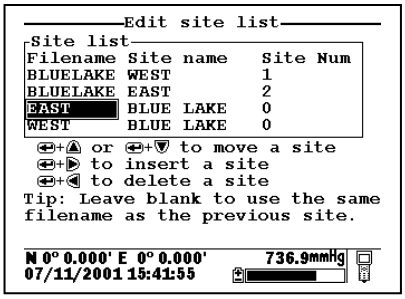


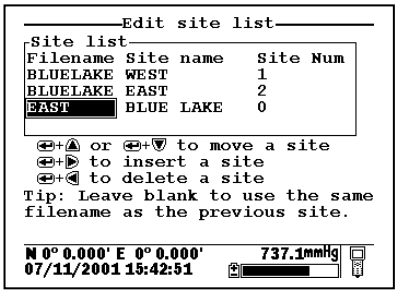
Note that the keystrokes for editing the site list are shown in the bottom of the Main Display. Thus, to insert (add) a file above the present cursor position, simply highlight the proper entry and press the **Right arrow** key while holding down the **Enter** key as shown in the following example. Note that two sites were inserted in the initial site list using this method.



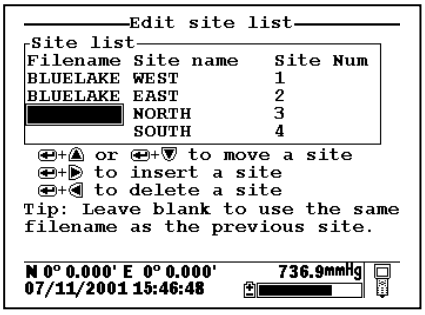


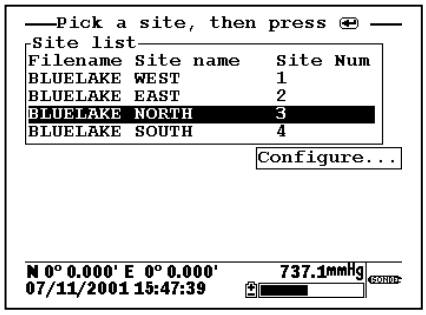
The two inserted entries can be moved either up or down in the list by highlighting them and pressing the **Up or Down arrow** key while holding down the **Enter** key or completely deleted by highlighting the entry and pressing the **Left arrow** key while holding down the **Enter** key as shown below.





Finally, the user should be aware of a timesaving tip that is displayed when the **Filename** entry is highlighted. The tip allows much easier generation of **Multi-Site Designations** where the **Filename** is identical for several files. To "copy" the Filename from the previous file to a new entry below, simply highlight the new **Filename** block, press **Enter** and then enter site names and site numbers**.** The site list will show these blanks in the **Edit site list** mode as shown on the left below, but when the site list is accessed for logging studies the actual **Filename** will appear to avoid confusion. This is shown at the right below. Note that, by using this tip, two new sites have been easily added to the BLUELAKE Multi-site list with no need to enter "BLUELAKE" Filename for each new site.





Remember that, when editing your Site list, you will have no effect on the actual files which were previously logged to 650 memory nor on the data in the files. See Section 3.6 below.

3.5.4 650 LOGGING – "CANS" AND "CAN'TS"

The use of the 650 to facilitate the storage of data from YSI 6-series sondes has been described in some detail in the sections above. Unfortunately, the high levels of capability and flexibility of the 650 logging function might also be viewed as complexity which, in turn, can confuse some users about how to employ the 650 in their particular application. This section is designed to help with any confusion that exists by listing what "can" be done with the 650 logging system and what "can't" be done.

3.5.4.1 SUMMARY OF 650 LOGGING CAPABILITIES

WITH A 650/YSI SONDE SYSTEM, THE USER CAN:

- Log sonde sensor data to either sonde memory (if your sonde is so equipped) or 650 memory.
- Log data as either a single point or as a continuous data stream.
- Log data in both single point form and continuous stream form to the same file in 650 or sonde memory.

- Log continuous data stream data at long or short sample intervals to sonde memory, as long as the study is started from the Run menu of the sonde.
- Log continuous data stream data at long or short sample intervals up to 15 minutes to 650 memory using the **Sample interval** selection in the **Logging setup** menu of the 650.
- Log data from the 650 internal barometer to the memory of the 650.
- Log data from a user-supplied GPS unit to the memory of the 650, as long as the GPS unit is set up in NMEA format and has the proper cable.
- Log data with minimal keypad entry from the 650 display by using default file naming.
- Assign custom file and site names using the 650 keypad at the logging site.
- Set up custom site lists in the office or laboratory that are instantly available in the field to simply file/site management.
- Set up Site Designations that are characterized by a File Name and a Site Name for simple logging of data from a single site to a single file.
- Set up Site Designations that are characterized by a File Name, a Site Name, and a Site number which correlates with the Site name. These lists allow the logging of data from more than one site to the same file.
- Easily view data on the 650 display that has been stored to either sonde or 650 memory.
- Easily upload data that has been stored in either sonde or 650 memory to a PC for analysis using EcoWatch for Windows software from YSI.

3.5.4.2 SUMMARY OF 650 LOGGING LIMITATIONS

WITH A 650/YSI SONDE SYSTEM, THE USER CANNOT:

- Log GPS and/or barometer data to sonde memory.
- Log GPS and/or barometer to 650 memory without a sonde attached and the 650 in **Run** mode. See Sections 3.8.2 and 3.9.4 below.
- Log data to existing files in 650 memory if the data format does not EXACTLY match that of the data already in the file. Typical examples of this type of “file mismatch” include:
    - Attempting to append existing data files after changing the parameter list.
    - Attempting to append existing data containing a Site Number to a file that contains data without Site numbers.
    - Attempting to append existing data containing NO site number to a file that contains data with Site numbers.
    - Attempting to append existing files containing GPS and/or barometer data after deactivating the storage of these parameters in **Logging setup**.

- Delete individual files from 650 or sonde memory. The memory is "flash" and therefore all files must be deleted in order to regenerate the storage capacity.

- Enter more than 8 characters for a File name or more than 13 characters for a Site name.

3.6 MANAGING 650 FILES

3.6.1 INTRODUCTION

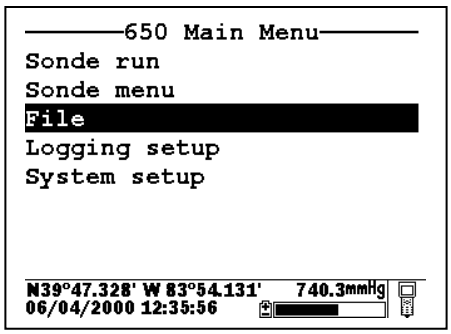
This section deals with the management of data that have been placed in 650 memory either through direct logging from your sonde or from the upload of data stored in sonde memory. A "file" by definition contains data and is distinct from the **Site Designations** in a **Site list** that are used to configure actual data files. For example, deleting an entry from the site list after points have been logged under this designation will have no effect on the actual logged data, i.e., the file itself will still be present in 650 memory. Conversely, deleting data files from the 650 memory will not delete the **Site Designations** from the **Site list**. The management of data stored in the 650 is controlled from the **650 File** command; the management of the list of file/site designations is controlled from the **Edit site list** command in the **650 Logging setup** menu as described in Section 3.5.3.4 above. Understanding this distinction will help the user avoid confusion in file and site list management.

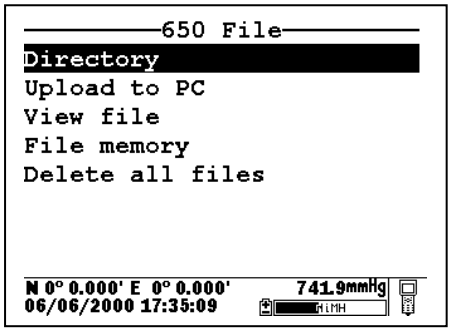
It is also important to remember that, as described in Section 3.2.2 above, the memory of the 650 is "flash" and that, while this type of memory has many advantages, its use does impose two limitations on file management.

1. The files are listed in the order that they are logged to memory and this order cannot be changed.

2. It is not possible to delete individual files to free up memory. The only way to regenerate the 650 memory is to delete ALL files present, i.e., format the flash.

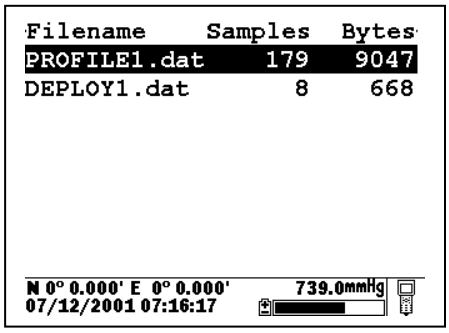
To proceed with the details of 650 File management, turn the instrument on, highlight the **File** entry in the **650 Main menu,** and press **Enter** to display the File commands as shown below.



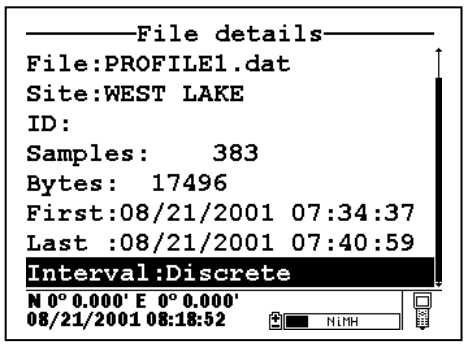


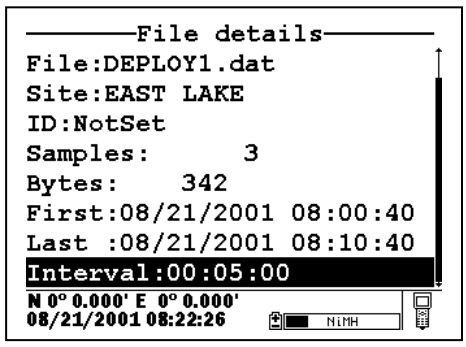
3.6.2 DIRECTORY

Use the arrow keys to highlight the **Directory** selection in the **650 File** menu and press **Enter** to display the list of files resident in the 650 memory.



Note that the size of the file is shown in two different ways: (1) the number of samples (logged data points of several parameters) and (2) the total number of bytes of memory occupied by the file. Highlight the top file (PROFILE1) and press **Enter** to generate a display of the details of this file. Press **Escape** and then highlight the second file (DEPLOY1) and press **Enter** to again display information about the file.

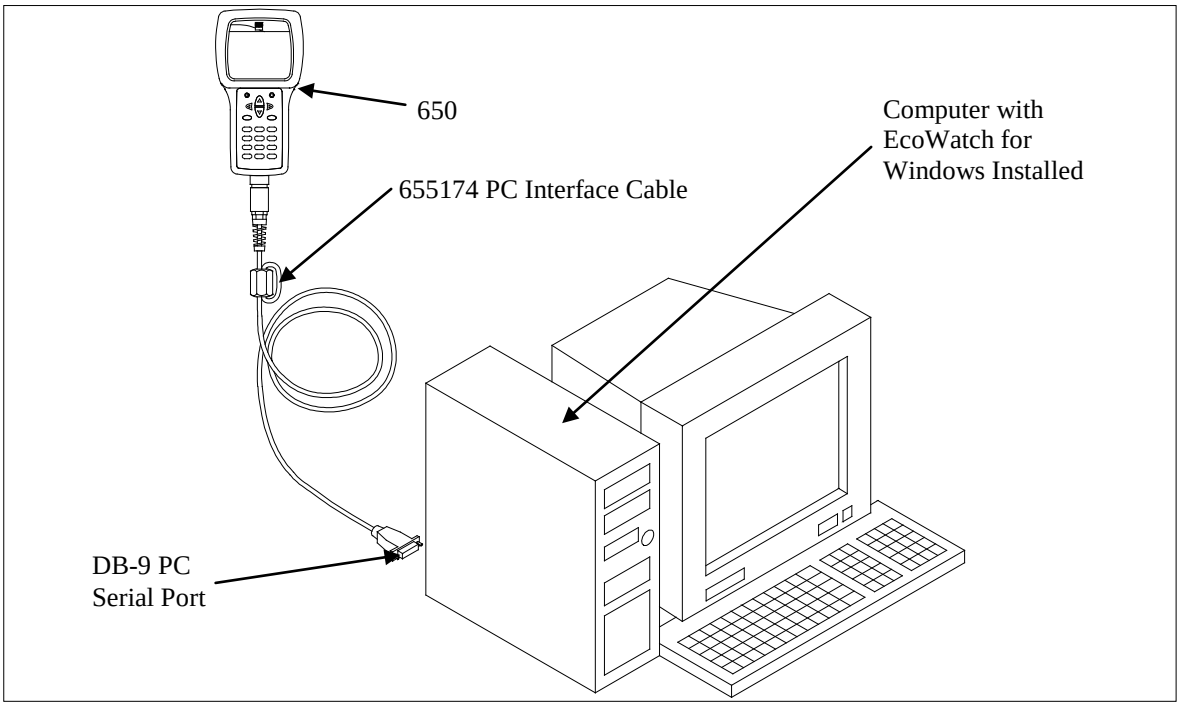




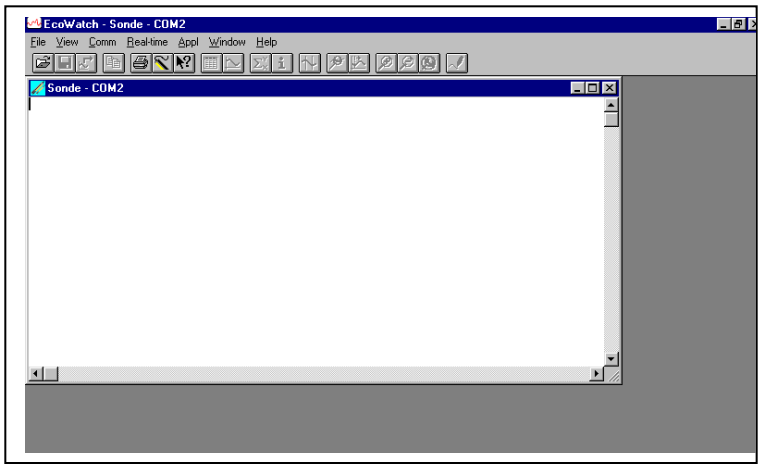
For both files, the file name, site name, file size and time of the first and last samples logged are shown. The information under **Interval** will identify whether the data were logged by manual control of the system (Discrete) or to the memory of a sonde set up in an **Unattended sampling** study. Only for **Unattended sampling** studies will the actual sample interval be displayed. When the Interval has the designation "Discrete", the time between samples can be determined by viewing the data as described below.

3.6.3 UPLOAD TO PC

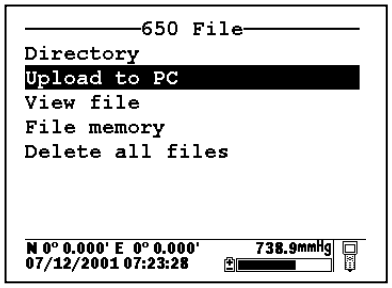
This frequently used command is used to transfer data files resident in the 650 memory (either logged directly or uploaded from sonde memory) to a PC that is running YSI EcoWatch for Windows software. Once transferred, the data can be custom configured, plotted, and reported in tabular form using this software package. The data can also be exported from EcoWatch in spreadsheet compatible form if the user prefers this method of data analysis and management. In order to carry out the upload of data files to your PC, you must first connect the 650 to a serial port of your computer via the 655174 PC Interface cable as shown in the following diagram:

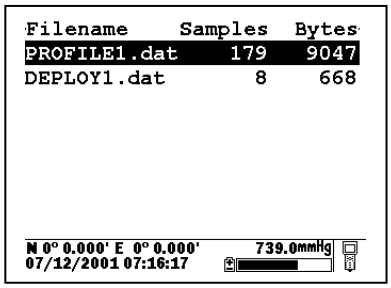


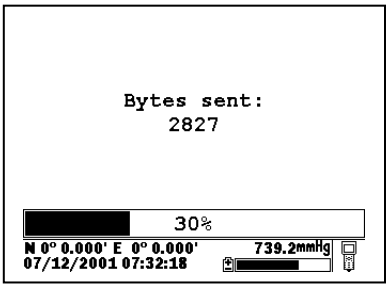
After the connection is made, run EcoWatch for Windows, click on the sonde icon in the upper toolbar, and set the Comm port number to match your interface. After this setup procedure, the following screen will be present on your PC monitor:



To transfer data from the 650 to your PC, highlight the **Upload to PC** selection in the 650 File menu and press **Enter** to view a list of the files. Highlight the file that you wish to transfer and press **Enter**. The 650 and PC displays will show the progress of the file transfer until completion.





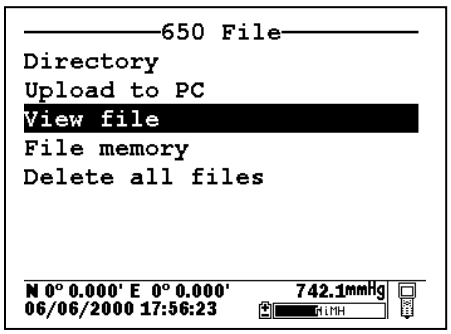


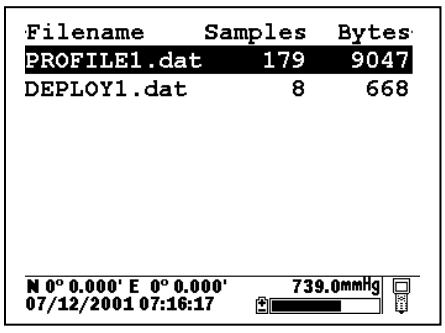
Note that there are three file types (with different extensions) in the above directory: (1) Files with .dat extensions which are data files logged to either sonde memory of 650 memory and which are in YSI PC6000 format; (2) Files with a .txt extension which are data files logged to sonde memory and then transferred to 650 memory in either ASCII or CDF format; and (3) Files with a .glp extension which are calibration records of either the sonde sensors or the 650 barometer. For files with a .dat or .txt extension, transfer to a PC using the **Upload to PC** command will proceed automatically and retain the file type that is present in 650 memory. For files with a .glp extension, an additional screen will appear on activating the transfer that gives a choice of binary, CDF, or ASCII for moving the file to the computer. You currently MUST use either the CDF or ASCII format for transfer so that the .glp file can be viewed in NotePad or other word processing program. The binary transfer option is for future YSI upgrades.

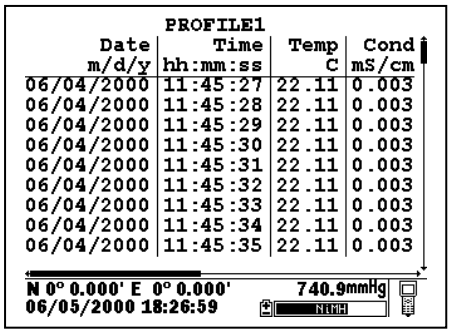
After transfer the file will be located in the C:\ECOWWIN\DATA subdirectory of your PC hard drive.

3.6.4 VIEW FILE

The **View file** selection in the 650 File menu allows the user to examine the data in files logged or uploaded to 650 memory. Highlight the **View file** selection and press **Enter** to display a list of files present. Then highlight the file of interest and press **Enter** to view the data on the 650 display.



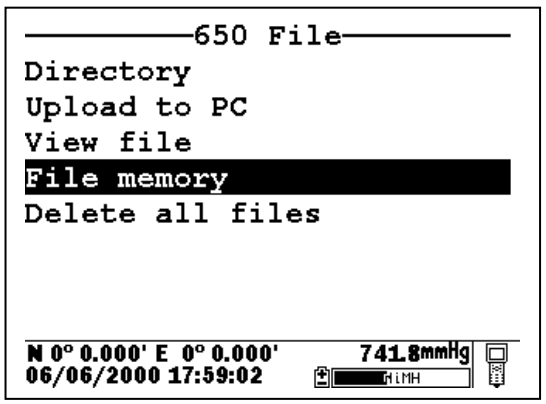


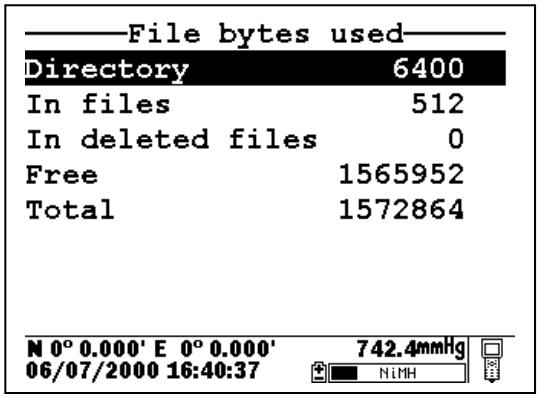


Use the arrow keys to scroll vertically to view more data points with regard to time or horizontally to view more sensor data within a particular data entry. The vertical and horizontal scroll bars identify your location within the data file.

3.6.5 FILE MEMORY

The **File memory** selection in the 650 **File menu** allows the user to get a complete picture of how the memory of the instrument is presently allocated. To view details of the allocation, highlight **File memory** and press **Enter** to display the following screen.





The key number in the **File bytes used** display is the **Free** memory listing which can be used to determine when you need to format the 650 memory ("Delete all files" as described in the next section). The value under **Total** memory will reflect whether you purchased a 650 with high or low memory. The top three items in the display summarize the allocation of the used memory space. In the example above, 6400 bytes are used in defining the memory directory, 512 bytes are taken up with accessible files, and 0 bytes are taken up in "deleted" files. As described in Section 3.2.2 above, "deleted" files arise when the same file is uploaded from a sonde several times with the file "overwritten".

There is a lot of information on the **File memory** display, but the number of greatest importance is the **Free** memory value.

3.6.6 DELETE ALL FILES

Use this selection to remove all files from the 650 memory. Remember that you cannot delete individual files from flash memory. Highlight the selection and press **Enter**. Use the arrow keys to confirm that you really want to delete all files and press **Enter**.

CAUTION: When you use this command, all data currently stored in the 650 memory will be irretrievably lost, so make certain that you have transferred all files of interest to your PC before carrying out the procedure. Note, however, that use of the **Delete all files** command will have no effect on any **Site Designations** which have been entered from the **Edit site list** selection.

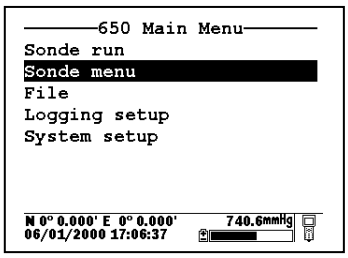
3.7 UPLOADING DATA FROM SONDES

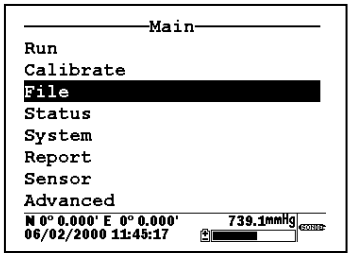
3.7.1 INTRODUCTION

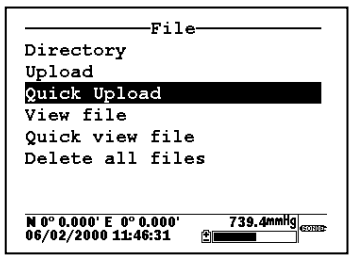
A primary function of the 650 is to serve as an intermediate location for transfer of data stored in deployed 6-series sondes to a PC without bringing the sondes back to the base facility. In this application, the user connects the 650 to the sonde at the deployment site via a standard YSI field cable and, using the proper keypad commands, transfers the data stored in the sonde to the memory of the 650. The sonde is then redeployed without disturbing the study and the data transferred to a PC on return to the base facility.

3.7.2 UPLOAD PROCEDURE

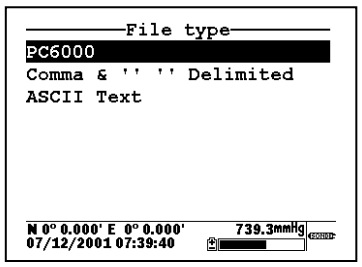
After attachment of the sonde to the 650 with a YSI field cable, turn on the 650, highlight the **Sonde menu** selection and press **Enter** to display the Main sonde menu. Highlight the File selection and press **Enter**.
NOTE: The upload MUST be made from the File menu of the sonde, not the File menu of the 650.

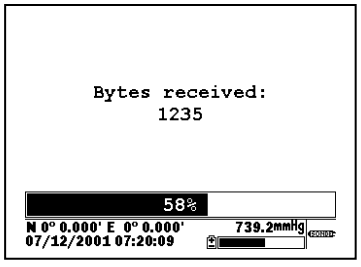


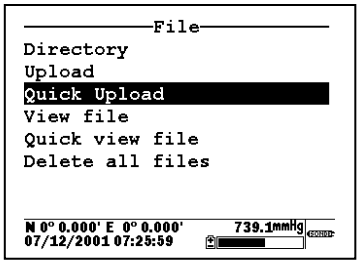




Select the **Upload** or **Quick upload** (last file) and press **Enter**. Then follow the instructions including selection of file format – YSI recommends the PC6000 format. Press **Enter** and the display will indicate that upload of data from sonde to 650 is in progress as shown below. When the upload is complete, the display will return to the **Sonde File** menu.







After the sonde file has been uploaded to the 650, the data is resident in the flash memory of both sonde and 650. Note that, if you choose to upload files from the sonde in CDF or ASCII format, the files will be characterized by a .txt extension in the 650 Directory and will NOT be viewable on the 650 display. To view the files, you must first transfer them from the 650 to your PC and then open them in a spreadsheet.

3.8 USING GPS WITH THE 650

3.8.1 SETTING UP THE GPS-650 INTERFACE

The 650 allows the user to display GPS readings of latitude and longitude from a commercially-available, user-supplied unit in the Status Bar of the 650 display. The interface of the GPS unit to the 650 is

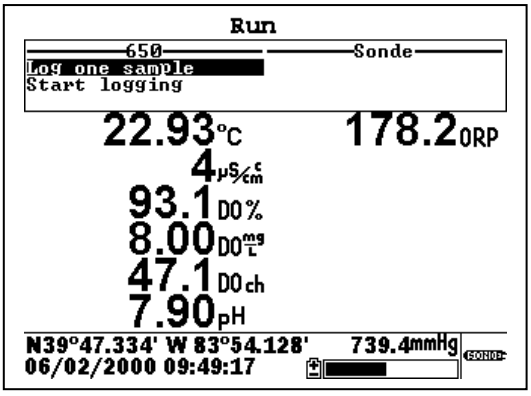
accomplished via the 6115 GPS cable that can be purchased as an optional accessory. Using the 6115 cable, GPS readings can also be logged to the 650 memory along with sonde sensor readings taken at a particular geographical location, which can then be relocated for subsequent studies.

The use of the GPS interface is easy, but the user must configure the hardware and software of the GPS unit as follows before proceeding:

- Consult the user manual of the GPS unit and configure the instrument so that readings in the NMEA 0183 protocol are generated.
- Purchase from your GPS manufacturer a cable that connects at one end to the GPS unit and has at its other end a female DB-9 connector for interface with the YSI 6115 GPS cable.

Once these requirements are met, proceed according to the following instructions, consulting Figure 2 in Section 3.2.3 above for assistance:

- Connect the 6115 GPS cable to the 650 via the MS-8 connector.
- Connect the other MS-8 connector of the 6115 GPS cable to the MS-8 connector or your sonde cable.
- Attach the male DB-9 connector of the 6115 GPS cable to the mating female connector of your GPS unit.
- Turn on the 650 and make certain that appropriate GPS readings are displayed in the upper left corner of the Status Bar as shown in the following display.



3.8.2 LOGGING GPS READINGS

To log latitude and longitude readings from a user-supplied GPS unit, the following conditions must be met:

- GPS readings can ONLY be logged to 650 memory – the system does NOT support logging to sonde memory.

- The GPS readings must be logged to 650 memory from the **650 Run** display along with sonde sensor readings. This means that you must have a sonde attached to your 650 via the 6115 cable in order to log GPS readings. Logging of GPS readings is not supported without sonde attachment even though these readings can be viewed in the Status Bar with no sonde attached.

- If your want to log the GPS readings to 650 memory along with sonde sensor readings at a particular location, you must make certain that the **Store Lat and Long** option is active in the **Logging setup** menu of the 650.

Once these conditions are met, follow the instructions in Section 3.5.3 above for logging of sonde sensor readings to 650 memory. The GPS readings will automatically be added to the file at the sample interval selected for the sonde readings.

GPS readings stored in 650 memory will remain as part of the sensor data file that can be viewed from the 650 display and/or uploaded with the data file for analysis in EcoWatch for Windows. Latitude and longitude are, however, displayed somewhat differently by the 650 and EcoWatch as noted below:

- For both display formats, the GPS are indexed relative to the point where the Greenwich Mean Time line crosses the equator.

- For the 650 Status Bar, readings are displayed in degrees and then decimal minutes relative to this point with actual "N" (north), "S" (south), "E" (east) and "W" (west) designations relative to the index point.

- When analyzing data in EcoWatch, the user will have the choice of two formats, decimal degrees (e.g., 47.5400 degrees) or degrees/decimal minutes (e.g., 47 ^{o} 32.400'). For EcoWatch, alpha directional characters ("N", "S", "E", and "W") are NOT used. Instead, points north and east of the index point are designated as positive, while points south and west are designated as negative.

These criteria mean that the GPS coordinates of Yellow Springs, Ohio, USA are approximately 39 ^{o} 47.33' latitude and -83 ^{o}54.13' longitude as read in EcoWatch, but N 39 ^{o} 47.33' W 83 ^{o} 54.13' as displayed by the 650.

3.9 USING THE 650 BAROMETER

3.9.1 PRINCIPLES OF OPERATION

The optional barometer operates on the strain-gauge principle and is located on the internal PCB of the 650. To make certain that the barometer is sensing true atmospheric pressure under conditions of temperature and pressure changes, the interior of the case is vented to the atmosphere with patches of material which are permeable to air, but impermeable to water. One of these patches is located in the rear section of the case and the other is attached to the battery lid. The patch on the case rear is not accessible to the user, but the one on the battery lid can be damaged by abuse. Be certain to identify the location of the patch on the interior of the battery lid and take care not to puncture it with sharp objects or to peel it away from the plastic. If you suspect that the venting patch on your battery lid has been damaged, make certain that you do not expose the 650 to water (either spraying or submersion). Then contact YSI Technical Support as soon as possible for advice.

The 650 barometer reads true barometric pressure and therefore is unlikely to agree with values from your local weather service which are usually corrected to sea level before being distributed. Note, however, that the primary purpose of the barometer is for use in calibrating your sonde dissolved oxygen sensor and the "true" value as shown in the 650 Status Bar is the required parameter for this procedure.

3.9.2 CALIBRATING THE BAROMETER

The 650 barometer is factory calibrated to provide accurate readings in the 500-800 mm Hg range which will be useful for dissolved oxygen calibration at most locations. This factory calibration should provide readings that are useful for dissolved oxygen calibration for many months with no user attention. However, if the user wishes to either increase the accuracy of the sensor in the local barometric pressure range or to compensate for

the small drift associated with any sensor, the 650 provides a single point calibration routine which is accessed in the **650 System setup** menu and is described in Section 3.3.5 above.

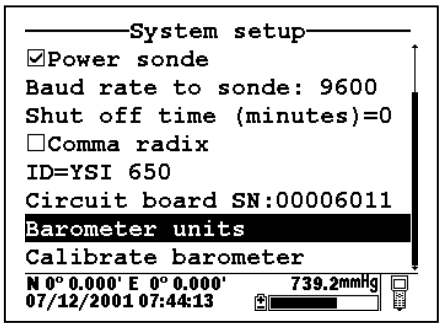
The critical factor in carrying out the single point calibration is the accuracy of the "standard" barometer that is used to determine the true barometric pressure. Common sources of this "standard" reading are high quality laboratory barometers (either mercury-based or electronic) and data from your local weather service. Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for a standard as long as the system is known to be accurate. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected". An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:

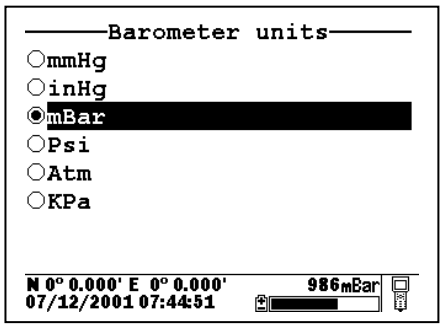
True BP = [Corrected BP] – [2.5 * (Local Altitude/100)]

Overall, the key point to remember in calibration of your barometer is to make certain that your "standard" reading is correct. If the "standard" is not accurate, you are likely to do more harm than good with your user-calibration.

3.9.3 CHANGING BAROMETER UNITS

The 650 offers the user a choice of six commonly used units of barometric pressure which can be displayed in the Status Bar. When received from the factory, the 650 will show values in mm Hg. If the user wants to change to other units, the selection is found in the **650 System setup** menu as shown below. Highlight the selection and press **Enter** to show the possible units. Then highlight the unit of choice and press **Enter** to activate it. The barometer reading in the Status Bar will automatically change to the newly selected unit.





3.9.4 LOGGING BAROMETER READINGS

To log barometric pressure readings with the 650, the following conditions (similar to those above for logging GPS readings) must be met:

- Barometer readings can ONLY be logged to 650 memory – the system does NOT support logging to sonde memory.

- The barometer readings must be logged to 650 memory from the **650 Run** display along with sonde sensor readings. This means that you must have a sonde attached to your 650 in order to log barometer readings. Logging of barometer readings is not supported without sonde attachment even though these readings can be viewed in the Status Bar with no sonde attached.

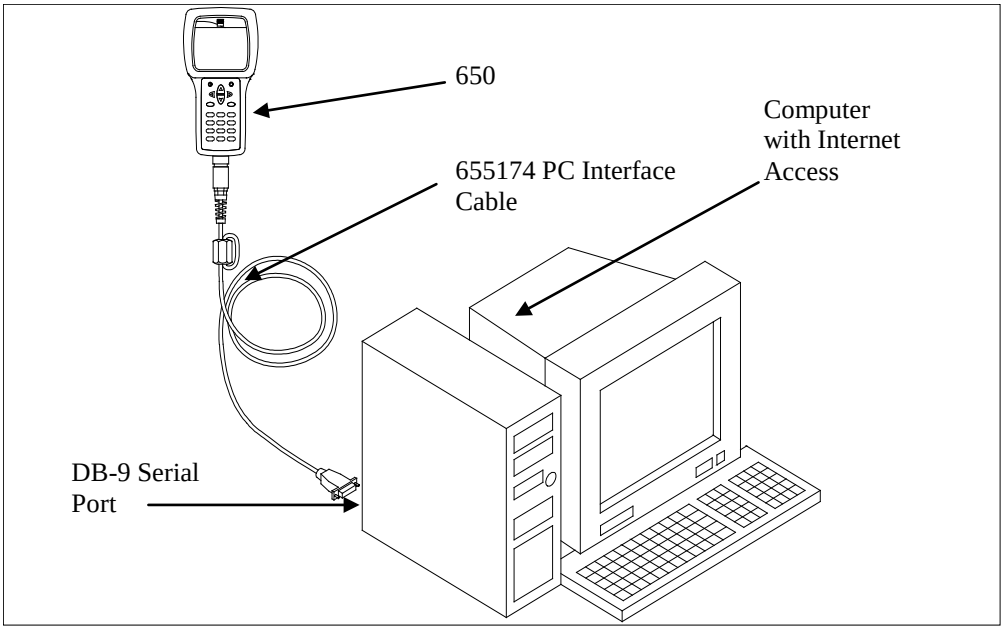
- If your want to log barometer readings to 650 memory, you must make certain that the **Store Barometer** option is active in the **Logging setup** menu of the 650.

Once these conditions are met, follow the instructions in Section 3.5.3 above for logging of sonde sensor readings to 650 memory. The barometer readings will automatically be added to the file at the sample interval selected for the sonde readings.

Barometer readings stored in 650 memory will remain as part of the sensor data file that can be viewed from the 650 display and/or uploaded with the data file for analysis in EcoWatch for Windows. The barometric pressure readings are processed as a normal parameter by EcoWatch, with the user having the ability to change units from the EcoWatch menus. For example, data stored in 650 memory in units of mm Hg units can easily be converted to readings in mBar after upload.

3.10 UPGRADING 650 SOFTWARE

The 650 software can easily be upgraded from the YSI World Wide Web page (www.ysi.com). However, before accessing the Web page, the instrument should be prepared for upgrade by attaching the MS-8 end of the YSI 655174 PC Interface cable to the 650 and the DB-9 end of the 655174 to a serial port of a PC which has Internet access as shown below:



Once the setup is complete, access the YSI Web Page and locate the section on software upgrades. Select the 650 upgrade entry and follow the instructions provided on the Web Page. If you encounter difficulties in the upgrade procedure, contact YSI Technical Support for advice.

3.11 TROUBLESHOOTING

The following sections describes problems which you might encounter when using the 650 MDS and provides suggestions which might allow the user to overcome the symptom without additional assistance.

PROBLEM	POSSIBLE SOLUTION
No display is visible after pressing the on/off key.	If C cells are used, make certain that they are installed properly with regard to polarity and that good batteries are used. If a rechargeable battery pack is used, place the pack in the instrument and charge for 30 minutes.
No interaction with the sonde occurs when pressing **Sonde run** or **Sonde menu** from the 650 menu.	Make certain that (a) the cable is connected properly between sonde and 650 and (b) that Sonde power is activated in the 650 **System setup** menu.
Instrument software appears to be locked up as evidenced by no response to keypad entries or display not changing.	First, attempt to reset the instrument by simply turning off and then on again. If this fails, remove battery power from the instrument for 30 seconds and then reapply power. When using C cells, remove the battery lid and one of the batteries; when using the rechargeable battery pack, remove the pack completely from the instrument. After 30 seconds replace the battery or battery pack and check for instrument function.
Upload of files to 650 from sonde fails.	(1) Make sure that cable is connected properly to both 650 and sonde; (2) Make certain that you are accessing the upload routine from the sonde File menu and NOT from the 650 File menu.
Upload of files from 650 to PC fails	1) Make sure that cable is connected properly to both 650 and PC; (2) Make certain that the proper Comm port is selected in EcoWatch for Windows.
GPS and/or barometer data is not stored with sonde data file.	Make sure **Store barometer** and **Store Lat and Long** are active in 650 **Logging setup** menu.
Site Designations in the **Site List** are "grayed-out" and not available for appending files with additional data. A "Parameter Mismatch" screen is displayed.	There is a parameter mismatch between the current 650 setup and that initially used. Use **650 File view** and the Parameter Mismatch screen to determine the sonde parameter, barometer, and GPS format of file already present in memory and readjust the setup to match that initially used.
GPS data is not shown in Status Bar.	Make sure that (a) the cables are attached properly; (b) that the GPS unit is configured for NMEA 0183 format; (c) that the GPS unit is "locked in" and that the GPS unit display is showing proper readings.
The 650 display flashes and the instrument speaker makes a continuous clicking sound.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.
The sonde/650 resets when optical wipers are activated in the sonde.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.

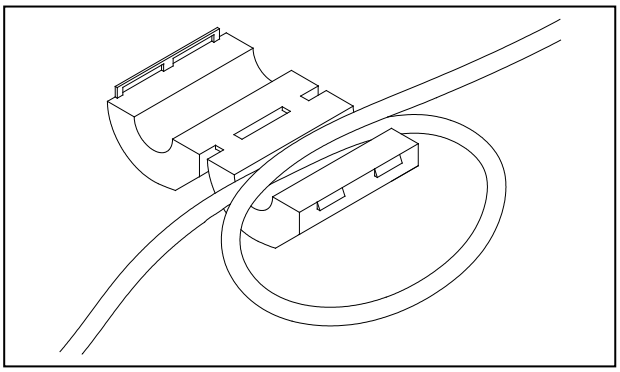
If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Technical Support for advice. See Section 8 of the 6-series manual for contact information.

3.12 FERRITE BEAD INSTALLATION

WARNING: If you are using your 650 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655174 PC Interface Cable and the 6116 Charger Adapter Cable in order to comply with the Residential, Commercial and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are supplied as part of cable kits.

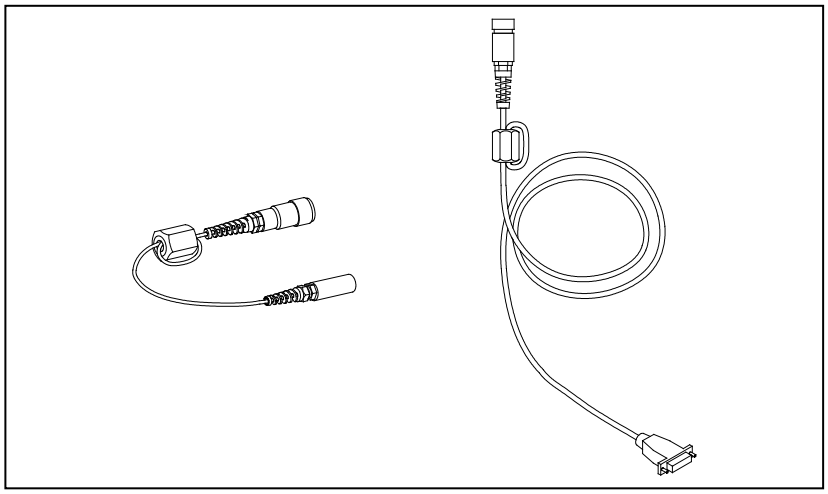
To install the beads, follow these steps:

- Make a small loop (approximately 5 cm in diameter) in the cable near the 650 MS-8 connector.
- Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead. See the drawing below for assistance.



- Snap the two pieces of the bead together making certain that the tabs lock securely.

When the installation is complete, the 655174 and 6116 cables should resemble the following schematic drawings.



3.13 650 SAFETY CONSIDERATIONS

⚠IMPORTANT SAFETY INSTRUCTIONS!

⚠SAVE THESE INSTRUCTIONS!

⚠In essence, the most important safety rule for use of the 650 is to utilize the instrument ONLY for purposes documented in this manual. This is particularly true of the 6117 rechargeable battery pack that contains nickel metal hydride (NiMH) batteries. The 650 user should be certain to read all of the safety precautions outlined below before using the instrument.

⚠6113 Rechargeable Battery Pack Safety Information

⚠Restrictions on Usage

1. Never dispose of the battery pack in a fire.

2. Do not attempt to disassemble the 6117 battery pack.

3. Do not tamper with any of the electronic components or the batteries within the battery pack. Tampering with either the electronic circuitry or the batteries will result in the voiding of the warranty and the compromising of the system performance, but, more importantly, can cause safety hazards which result from overcharging such as overheating, venting of gas, and loss of corrosive electrolyte.

4. Do not charge the battery pack outside the 0-40 C temperature range.

5. Do not use or store the battery at high temperature, such as in strong direct sunlight, in cars during hot weather, or directly in front of heaters.

6. Do not expose the battery pack to water or allow the terminals to become damp.

7. Avoid striking or dropping the battery pack. If the pack appears to have sustained damage from these actions or malfunctions after an impact or drop, the user should not attempt to repair the unit. Instead, contact YSI Technical Support.

8. If the battery pack is removed from the 650, do not store it in pockets or packaging where metallic objects such as keys can short between the positive and negative terminals.

⚠Precautions for Users with Small Children

Keep the battery pack out of reach of babies and small children.

⚠Danger Notifications – Misuse creates a STRONG possibility of death or serious injury.

FAILURE TO CAREFULLY OBSERVE THE FOLLOWING PROCEDURES AND PRECAUTIONS CAN RESULT IN LEAKAGE OF BATTERY FLUID, HEAT GENERATION, BURSTING, AND SERIOUS PERSONAL INJURY.

1. Never dispose of the battery pack in a fire or heat it.

2. Never allow the positive and negative terminals of the battery pack to become shorted or connected with electrically conductive materials. When the battery pack has been removed from the 650, store it in a heavy plastic bag to prevent accidental shorting of the terminals.

3. Never disassemble the battery pack and do not tamper with any of the electronic components or the batteries within the battery pack. The battery pack is equipped with a variety of safety features. Accidental deactivation of any of these safety features can cause a serious hazard to the user.

4. The NiMH batteries in the battery pack contain a strong alkaline solution (electrolyte). The alkaline solution is extremely corrosive and will cause damage to skin or other tissues. If any fluid from the battery pack comes in contact with a user's eyes, immediately flush with clean water and consult a physician immediately. The alkaline solution can damage eyes and lead to permanent loss of eyesight.

⚠Warning Notifications – Misuse creates a possibility of death or serious injury

1. Do not allow the battery pack to contact freshwater, seawater, or other oxidizing reagents that might cause rust and result in heat generation. If a battery becomes rusted, the gas release vent may no longer operate and this failure can result in bursting.

2. If electrolyte from the battery pack contacts the skin or clothing, thoroughly wash the area immediately with clean water. The battery fluid can irritate the skin.

⚠Caution Notifications – Misuse creates a possibility of mild or serious injury or damage to the equipment.

1. Do not strike or drop the battery pack. If any impact damage to the battery pack is suspected, contact YSI Technical Support.

2. Store the battery pack out of reach of babies and small children.

3. Store the battery pack between the temperatures of –20 and 30 C.

4. Before using the battery pack, be sure to read the operation manual and all precautions carefully. Then store this information carefully to use as a reference when the need arises.

⚠616 Cigarette Lighter Charger Safety Information

1. This section contains important safety and operating instructions for the 650 cigarette lighter battery charger (YSI Model 616; RadioShack Number 270-1533E). BE SURE TO SAVE THESE INSTRUCTIONS.

2. Before using the 616 cigarette lighter charger, read all instructions and cautionary markings on battery charger, battery pack, and Model 650.

3. Charge the 6117 battery pack with the 616 cigarette lighter charger ONLY when the 6117 is installed in the YSI 650.

4. Do not expose charger to rain, moisture, or snow.

5. Use of an attachment not recommended or sold by the battery charger manufacturer may result in a risk of fire, electric shock, or injury to persons.

6. To reduce risk of damage to cigarette lighter and cord, pull by cigarette lighter rather than cord when disconnecting charger.

7. Make sure that the cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.

8. Do not operate charger with damaged cord or cigarette lighter connector – replace it immediately.

9. Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; contact YSI Technical Support.

10. Do not disassemble charger other than to change the fuse as instructed. Replace the part or send it to YSI Product Service if repair is required. Incorrect reassembly may result in a risk of electric shock or fire.

11. To reduce risk of electric shock, unplug charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

⚠650 Water Leakage Safety Information

The 650 has been tested and shown to comply with IP67 criterion, i.e. submersion in 1 meter of water for 30 minutes with no leakage into either the battery compartment or the main case. However, if the instrument is submersed for periods of time in excess of 30 minutes, leakage may occur with subsequent damage to the batteries, the rechargeable battery pack circuitry, and/or the electronics in the main case.

If leakage into the battery compartment is observed when using alkaline C cells, remove batteries, dispose of batteries properly, and dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Technical Support for instructions.

If leakage into the battery compartment is observed when using the 6117 rechargeable battery pack, remove the battery assembly and set aside to dry. Return the battery pack to YSI Product Service for

evaluation of possible damage. Finally dry the battery compartment completely, ideally using compressed air. If corrosion is present on the battery terminals, contact YSI Technical Support for instructions.

⚠**CAUTION:** If water has contacted the rechargeable battery pack, do not attempt to reuse it until it has been evaluated by YSI Product Service. Failure to follow this precaution can result in serious injury to the user.

If it is suspected that leakage into the main cavity of the case has occurred, remove the batteries immediately and return the instrument to YSI Product Service for damage assessment.

CAUTION: Under no circumstances should the user attempt to open the main case.

3.14 650 MDS SPECIFICATIONS

Resistance to Water Leakage: IP 67 for both the standard alkaline battery configuration and for the rechargeable battery pack option.

Operating Temperature Range for Visible Display: -10 to 60 Degrees Celsius

Storage Temperature Range: -20 to 70 Degrees Celsius

Dimensions: 9.13 inches long by 4.75 inches wide by 2.25 inches deep

Weight with 4 Alkaline C cells and no attached sonde or cable: Approximately 2.1 lbs. (960 g).

Display: ¼ VGA; LCD with 320 by 240 pixels with backlight

Connector: MS-8; Meets IP 67 specification

Standard Battery Configuration:

4 Alkaline C Cells with detached battery cover

Optional Battery Configuration:

Nickel Metal Hydride Battery Pack with attached battery cover and 110 volt charger

Battery Life:

Approximate battery life for typical sampling applications with 4 alkaline C cells – 3 hours of "on" time per day for 0.5 month (10 working days) with the meter powering a 6600 sonde with all probes active.

Approximate battery life for typical sampling applications with rechargeable battery pack – 3 hours of "on" time per day for 0.2 months (4 working days) with the meter powering a 6600 sonde with all probes active. Battery capacity restored completely with a 6-hour charge and charged to approximately 85 % with a 2-hour charge.

Barometer:

Range: 500 to 800 mm Hg
Resolution: 0.1 mm Hg
Accuracy: +/- 3 mm Hg within +/- 10° C of the calibration temperature

Communication Protocol:

RS-232 to all sondes and for data transfer to PC and for software updates

GPS via Y-cable – NMEA 0183

Standard Backlight Feature: 4 LEDs illuminating LCD

Keyboard: 20 keys including Meter On/Off, Backlight On/Off, Enter, Escape, 10 Number/Letter Entry Keys, 2 Vertical arrow keys, 2 Horizontal arrow keys, 1 minus/hyphen entry key, 1 decimal point/period

DECLARATION OF CONFORMITY

Manufacturer:	YSI Incorporated 1725 Brannum Lane P.O. Box 279 Yellow Springs, OH 45387 USA
Product Name:	Multiple Parameter Display/Data Logger
Model Numbers:	650 (with accessories: 6117 Rechargeable Battery Pack, 616 Vehicle Cigarette Lighter Adapter, 6116 Adapter Cable)
Conforms to the following:	
Directives:	EMC Directive
Harmonized Standards:	EN 61326: Electrical Equipment for Measurement Control and Laboratory Use. *Specifically the following:* Emissions Standard (EN 55011: Class B; Residential, Commercial & Light Industrial) Safety Standard (EN61010)

Supplementary information:

The Model 616 Vehicle Cigarette Lighter Adapter was evaluated for conformity to UL 2089, including testing per section 23, 24, 25, & 27, with no failures observed.

Exposure of Model 650 to conditions per EN61000-4-3 at 1000-Volts and EN61000-4-2 at 8-Kv Contact, caused loss of instrument status and software lock-ups. Exposure to conditions per EN61000-4-4 at 3V/m or EN61000-4-6 at 3VRMS may cause similar malfunctions. Chronic exposure may lead to damage.

Lisa Abel
Director, Quality Assurance

Date: February 16, 2007

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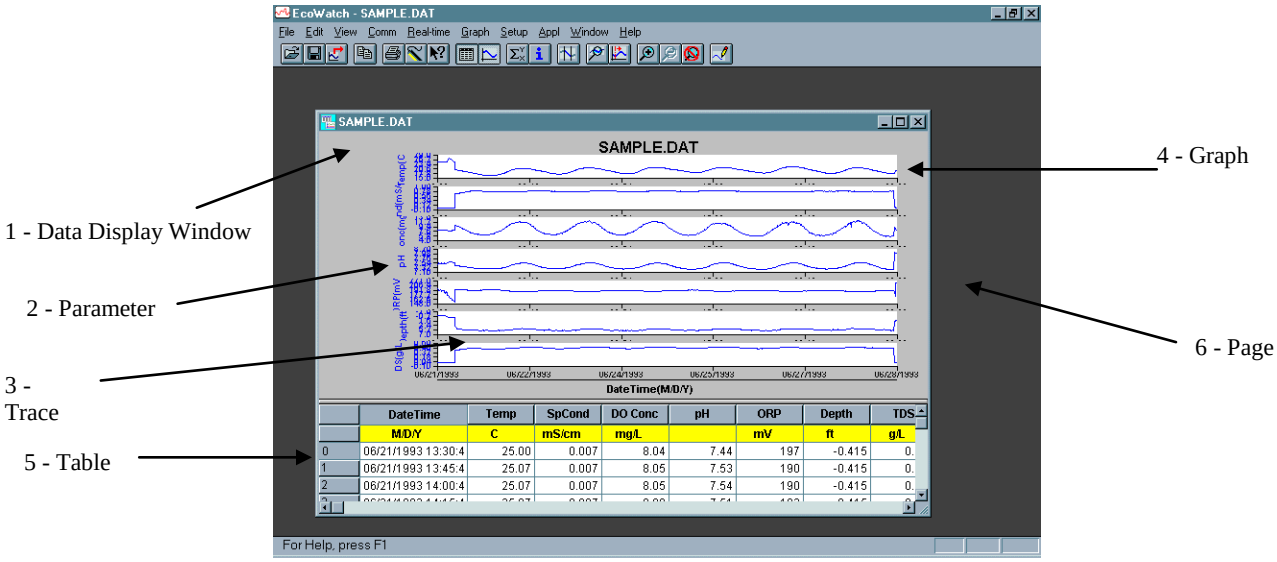
SECTION 4 ECOWATCH FOR WINDOWS

4.1 INTRODUCTION

EcoWatch for Windows is intended to be the PC software interface to YSI's 6-Series environmental monitoring systems equipment. From EcoWatch you can program field equipment, upload data collected on the equipment, and format the data in easy to understand graphs and tables.

4.1.2 GLOSSARY

These are a few of the more commonly used terms used in EcoWatch.



Term	Definition
1 - Data display window	The window that appears when you open a .DAT file.
2 - Parameter	A measurement such as temperature, dissolved oxygen, pH, etc. On a graph, the data of a parameter is displayed as a trace.
3 - Trace	The plot of the data of any one parameter. There may be one or two traces per graph.
4 - Graph	There may be one or more graphs depending upon how many parameters are selected. Each graph may have one or two traces. Data can be displayed either in graphs or in a table, or both.
5 - Table	Numbers arranged in rows and columns. Data can be displayed either in graphs or in a table, or both.

6 - Page

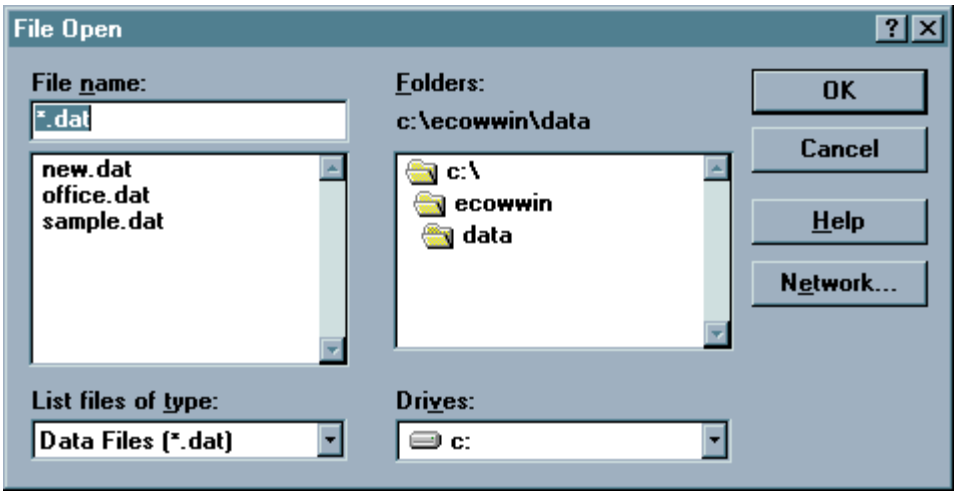
The Data Display Window can be divided in two pages, a graph page and a table page. A page becomes active when you click on it.

7 - Terminal window

This is the window that is open to display the sonde's internal menu. Allows the user to interact with the sonde or display/logger. The terminal window is a communication interface with another piece of equipment, whereas the Data Display Window is direct interaction with the EcoWatch software.

8 - Dialog box

A dialog box opens to display choices. Such as File Open.



9 – PC6000 data file

A data file that is in a format compatible with EcoWatch for Windows or PC6000 software.

9 – Study

A single data file in PC6000 format.

4.1.3 TUTORIAL

This brief EcoWatch tutorial is to be used with the sample data file that is provided with EcoWatch.

EcoWatch starts without an open data file (or .DAT file). When a data file is not open, a shortened menu bar is visible and many of the tools in the toolbar appear dimmed. Opening a data file will better demonstrate the capabilities of EcoWatch software.

To open the sample data file:

1. Click the **File** menu button in the toolbar.
2. Select the **SAMPLE.DAT** file.
3. Click **OK** to open the file.

Note that the data in this file appears as a graph of temperature, specific conductance, dissolved oxygen, pH, ORP, and depth, all versus time. The graphs are scaled automatically so that all data fits comfortably on the computer screen.

The **Table** and **Graph** buttons on the toolbar are on/off switches that are used to display or hide the graph and table pages respectively. When displaying a graph and a table at the same time, you can control the relative size of the two pages by placing the cursor over the small bar that separates them and then dragging it to the desired location.

From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs. Click **1 Trace per Graph** to return the display to the original setting.
Move the cursor to any position in the graph, then click and hold the right mouse button. Note that the exact measurements for this point in time are displayed to the left of the graph. While holding down the right mouse button, move to another area on the graph. Notice how the measurements change as you move. When you release the mouse button, the display returns to normal.
To view statistical information for the study, click the **Statistics** button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred. Double-click in the upper left of the Statistics window to return to the normal display.

End the tutorial by saving the Data Display in the format shown. To do this:

1. From the **File** menu, click **Save Data Display**.
2. Type Default for the file name when prompted for the Data Display Name.
3. Click **Save**.

The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data.

This demonstration shows only a small part of the capability of EcoWatch. You may wish to also review the procedures involved in the **Section 4.1.5**, **Typical Application**.

4.1.4 USING THE TOOLBAR

The EcoWatch toolbar includes buttons for some of the most common commands in EcoWatch, such as **File Open**. To display or hide the toolbar, open the **View** menu and click on the **Toolbar** command. A check mark appears next to the menu item when the toolbar is displayed.
The toolbar is displayed across the top of the application window, below the menu bar.

Click To:

Open an existing data file (.DAT). EcoWatch displays the **Open** dialog box, in which you can locate and open the desired file.

Save the working Data Display of the active data file. EcoWatch displays the **Save Data Display** dialog box in which you can overwrite existing Data Display or save to a new one.

Export data as a graph in Window Meta File (.WMF) format or as data in Comma Delimited (.CDF) format.

Copy the whole graph page or data from the selection on the table to the clipboard.

Print the active graph page or table page depending on which one is currently active.

Open a new terminal window to communicate with the sonde.

Access context sensitive help (Shift+F1).

Toggle table window during file processing.

Toggle graph window during file processing.

Display study statistics.

Display study info.

Limit the data to be processed in a study.

Enlarge a selective portion of graph.

Center the graph under the cursor.

Enlarge graph or table 20%.

Reduce graph or table 20%.

Return graph or table to its normal state (unzoom)

Redraw the graph.

4.1.5 TYPICAL APPLICATION

Suppose you want to measure Dissolved Oxygen, pH, Temperature, and Turbidity in a nearby stream and decide to start with a 30-day deployment using the YSI 6920 sonde. The task can be organized into several steps:

1. Calibrate and setup the sonde.

First connect your sonde to one of the serial communications ports on your PC. In the **Comm** menu, click **Sonde** and you will get a terminal window where you can calibrate the sonde and set it up for logging. You are now communicating directly with the sonde software. See **Section 2.6, Calibration** for more detailed instructions on calibration of sensors. See **Section 2.5, Sonde Software Setup** for sonde setup.

2. Deploy the Sonde

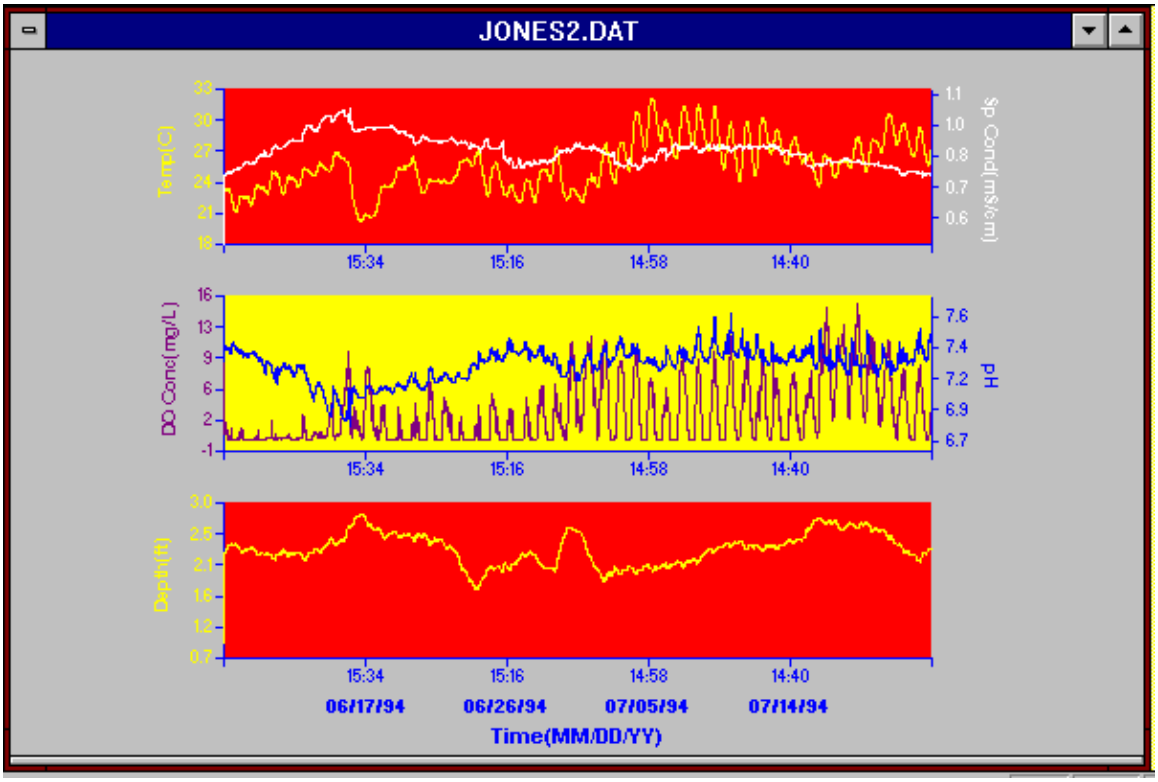
For more details, see **Section 2, Sondes and Section 3, Displays/Loggers**.

3. Retrieve the Sonde and Upload the Data

After retrieving the sonde, connect it to your PC and upload the data. As with calibration and setup, you can use the Sonde button in EcoWatch to communicate with the sonde. Using the sonde menu, upload the data to EcoWatch. The data will now be in a .DAT file on your PC.

4. Graph the Data and Adjust the Graphs to Your Liking

Open the newly uploaded .DAT file. In this example, the file is called JONES2.DAT. Upon opening the file it looks like the graphic at the end of this tutorial. You can then use the commands in the **Graph** menu to **Zoom** to the portion of the graph that you are most interested in. You can use the **Setup** menu to add a title or change colors, scale the graphs or select the parameters to be shown.



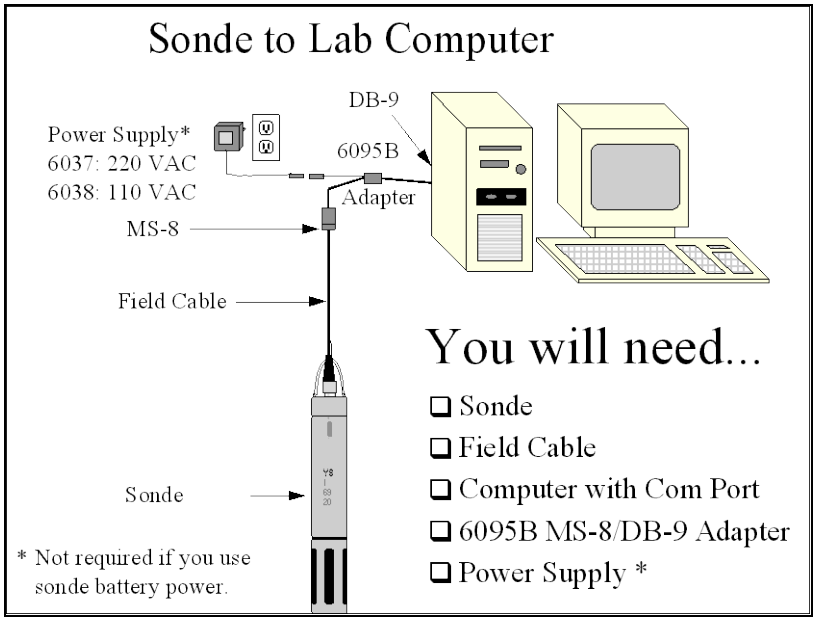
5. Print Your Graph

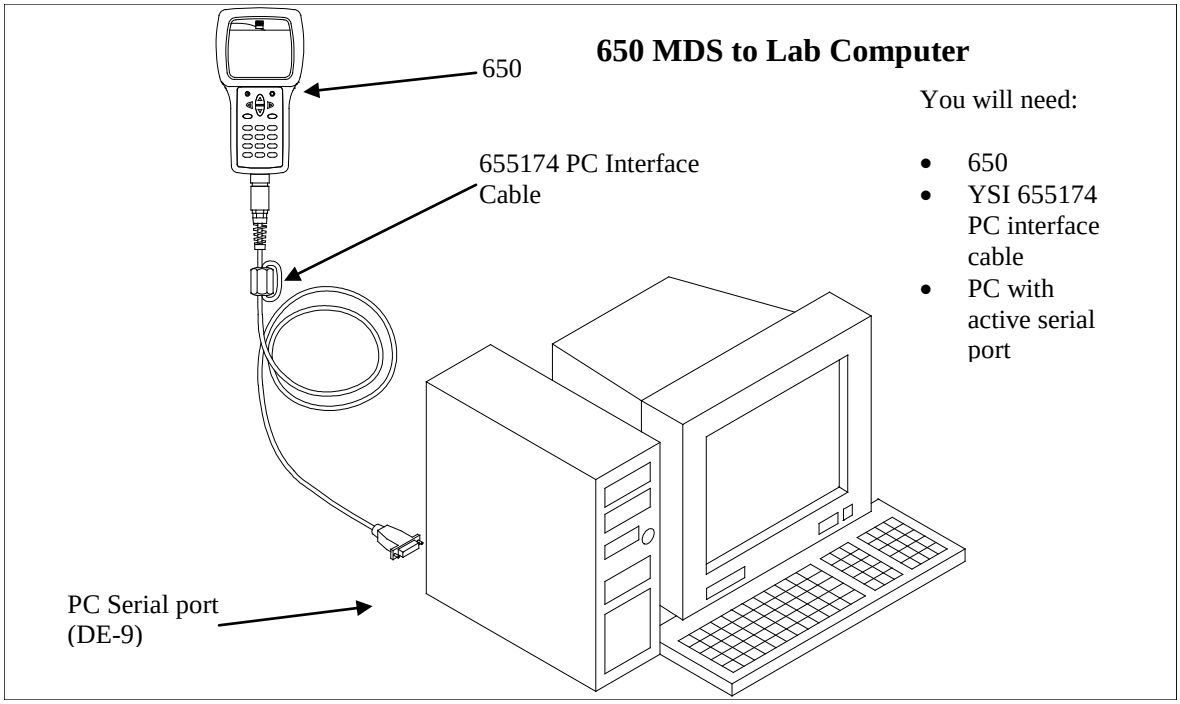
To print the graph, open the **File** menu, choose **Print Setup** or **Print** to choose exactly how the print should look.

4.2 DATA ACQUISTION AND ANALYSIS

4.2.1 CONNECT A YSI SONDE OR A 650 DISPLAY/LOGGER

EcoWatch may be used with various sondes or display/loggers. To utilize the configuration that will work best for your application, make sure that you have all of the components that are necessary.





A sonde or 650 display/logger must be connected to one of the serial communication ports on the back of your PC. These ports are usually referred to as COM1, COM2, etc. Most computers have at least two COM ports but they are often not labeled. To identify a COM port, look for unused 9 or 25 pin, D-shaped connectors with pin contacts.

Some sondes have integral cables and others require a separate cable sold especially for use with the sonde. Depending on the exact connector on your PC, you may also need a 9 to 25 pin adapter.

There is an PC interface cable for the 650 display/loggers that has a 9 pin D-shaped connector. This connector must be attached to your computer.

Once physically connected, you are ready to communicate using EcoWatch. Use the **Sonde** command in the **Comm** menu or the sonde button on the toolbar. This will give you a terminal window. From this window you interact with the sonde software using its menu system, or upload a file from a 650 display/logger. See **Section 2, Sondes** for details on how to use the sonde software.

4.2.2 UPLOAD A FILE FROM A SONDE

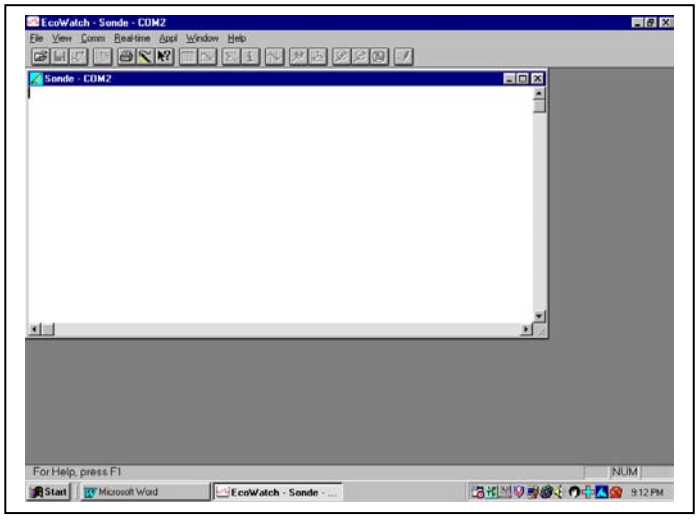
Data that is processed in EcoWatch typically originates in a sonde with batteries and is uploaded to a PC. To upload data from a YSI sonde, connect the sonde to your PC and open the EcoWatch software. Use the Sonde button on the toolbar to communicate with the sonde software.

Using the sonde software, go to the **Main menu** by typing "**menu**" on the blank terminal screen. Then choose **3-File Menu**. You will most likely be uploading the most recently recorded data. If so, simply press **3-Quick Upload**. Otherwise, press **2** to choose a file to upload. The sonde will ask you to choose a format for the file. Be sure to choose **PC6000 format**. After it is uploaded, the data will be in a **.DAT** file on your PC. You can then use EcoWatch to view, manipulate and print the data file.

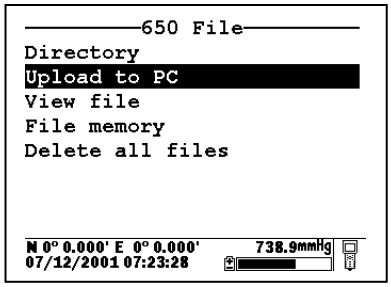
4.2.3 UPLOAD A FILE FROM A 650 DM DISPLAY/LOGGER

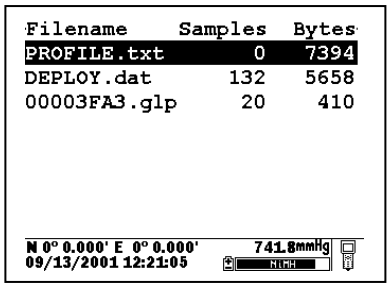
To transfer data files resident in the 650 memory (either logged directly or uploaded from sonde memory) to a PC that is running YSI EcoWatch for Windows software, you must first connect the 650 to a serial port of your computer via the 655174 PC Interface cable as shown in the diagram above.

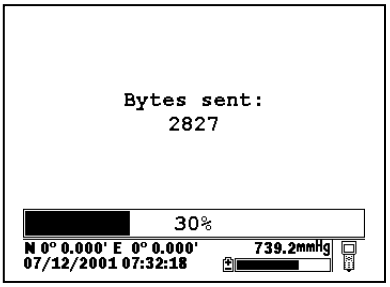
After the connection is made, run EcoWatch for Windows, click on the sonde icon in the upper toolbar, and set the Comm port number to match your interface. After this setup procedure, the following screen will be present on your PC monitor:



To transfer data from the 650 to your PC, highlight the **Upload to PC** selection in the 650 File menu and press **Enter** to view a list of the files. Highlight the file that you wish to transfer and press **Enter**. The 650 and PC displays will show the progress of the file transfer until completion.







Note that there are three file types (with different extensions) in the above directory: (1) Files with .dat extensions which are data files logged to either sonde memory of 650 memory and which are in YSI PC6000 format; (2) Files with a .txt extension which are data files logged to sonde memory and then transferred to 650 memory in either ASCII or CDF format; and (3) Files with a .glp extension which are calibration records of either the sonde sensors or the 650 barometer. For files with a .dat or .txt extension, transfer to a PC using the **Upload to PC** command will proceed automatically and retain the file type that is present in 650 memory. For files with a .glp extension, an additional screen will appear on activating the transfer that gives a choice of binary, CDF, or ASCII for moving the file to the computer. You currently MUST use either the CDF or ASCII format for transfer so that the .glp file can be viewed in NotePad or other word processing program. The binary transfer option is for future YSI upgrades.

After transfer the file will be located in the C:\ECOWWIN\DATA subdirectory of your PC hard drive.

4.2.4 USING THE GRAPH

Once uploaded, data can be easily displayed in EcoWatch. Open a **.DAT** file. The six buttons on right side of the toolbar help you get a closer view of that portion of the graph you desire.

Zoom Window

Use this to select a certain portion of the graph to be displayed. Click the button and then click and drag on the graph to select the portion you want to view. The pointer will change to a magnifying glass. The button will stay active until you click on it again.

Center Scroll

Use this to scroll through the study. Click the button and the pointer will change to a bullseye. Click anywhere on the graph and that spot will move to the center.

Limit Data Set

Use this button to reduce the data being processed and speed up operations. Click the button and move the pointer to the graph. A vertical arrow will appear with an N on the left and an Y on the right. Bracket the desired portion of the graph by moving the cursor to the left limit, clicking, moving to the right limit and clicking again. To limit the data in a table, move the pointer to the far left of the table into the row numbers area and highlight from the desired cutoff point to the beginning or end of the data set, whichever is desired. Then select the **Limit Data Set** option from the **Graph** menu or use the toolbar shortcut. To remove the limits, from the **Graph** menu choose **Cancel Limits**. You may also remove the limits using this button by clicking first on the right and then the left.

Unzoom

Use this button to view the study from the beginning limit to the end limit. This command can be used on both graphs and data tables.

Zoom In

Click this button to magnify by 20%. This command can be used on both graphs and data tables.

Zoom Out

Click this button to reduce magnification by 20%. This command can be used on both graphs and data tables.

4.2.5 GRAPH DATA IN REAL TIME

Choosing the **New** command from the **Real-time** menu will bring up a window with graphs that plot data from the sonde as the measurements are being taken. If you do not have a default COM port set in the **Communications Settings** dialog, then you will be asked which COM port to use for the real-time measurements. If you do have a default port selected, then the program will use that port automatically.

The number of parameters displayed during real-time is set by the sonde. If four parameters are set in the Report setup in the sonde, then those same parameters will be displayed in real-time. If you want to change the parameters displayed, then you must close the real-time window, open a sonde terminal window, change the number of parameters in the sonde software menu, and then return to real-time measurements.

The **Settings** command in the **Real-time** menu takes you to a dialog where you can set the x-axis time and the sample interval.

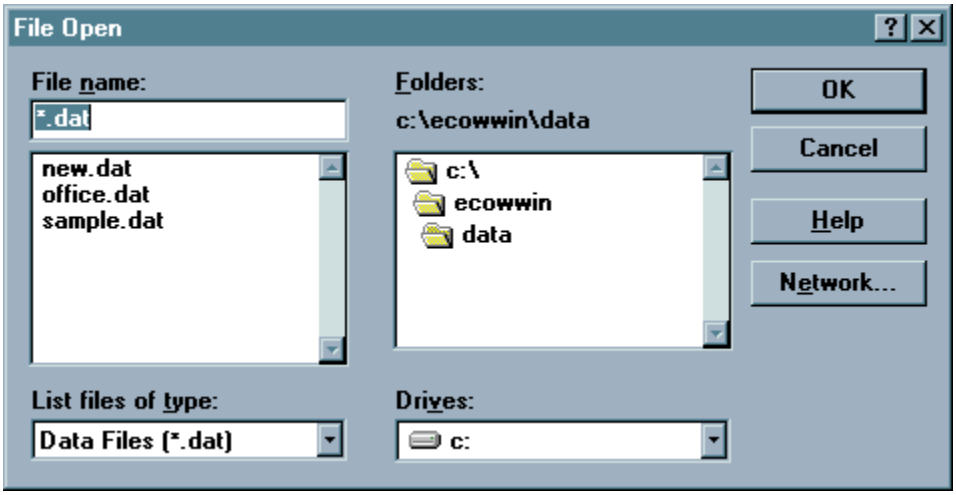
4.3 ECOWATCH MENU

4.3.1 FILE

The **File** menu offers the following list of commands. Some commands are available only when a file is open.

OPEN

Use this to open sonde data file (.DAT).



File Name Type or select the filename you want to open. This box lists files with the extensions you select in the **List Files of Type** box.

List of Files of Type Select the type of file that you want to open.

*.dat	Sonde binary data file
*.txt, *prn	ASCII text file
*.cdf, .csv, .sdf	Comma delimited file
*.rt	Real-time file
*.cr1	CR10 file

Drives Select the drive where the PC6000 data file resides.

Directories Select the directory where the PC6000 data file resides.

Network... Choose this button to connect to a network location, assigning it a new drive letter. This button is hidden if your computer is not connected to a network. The screen above has the network button hidden.

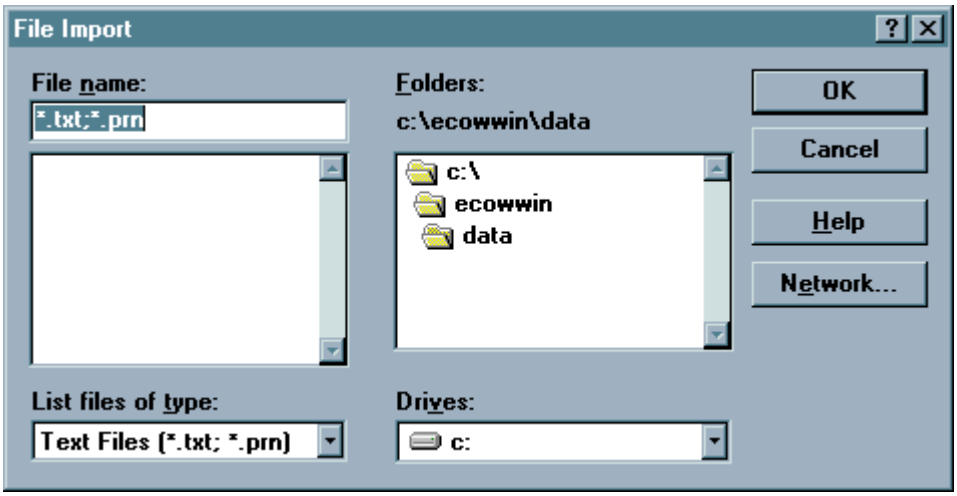
CLOSE

Use this command to close all windows containing the active document. EcoWatch automatically saves any changes before the file is closed.

You can also close a document by using the **Close** icon on the document's window, as shown below:

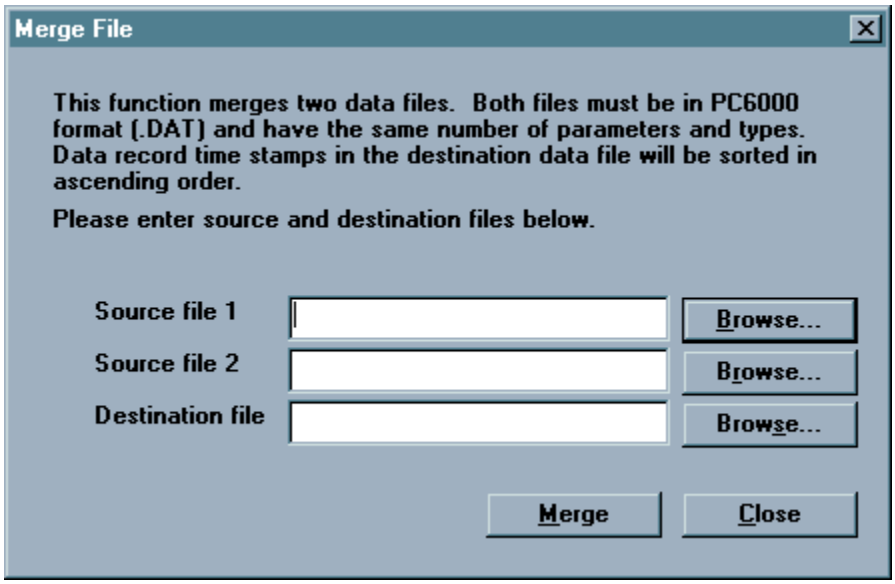
IMPORT

With this command, you can import common ASCII files into EcoWatch. The file will be converted into PC6000 format and again with a .DAT extension.



MERGE

This function takes two existing data files and merges them into one new file. Both files must be in PC6000 format (.DAT), have the same number of parameters, and the same parameter types (the parameter setup must be identical). Data record time-stamps in the destination data file will be stored in ascending order.



COPY TO CLIPBOARD

If a graph or table is active, then choosing this command will send its contents to the Windows clipboard so that it can be pasted into other programs. This is a normal method of transfer data between different Windows programs.

Shortcuts

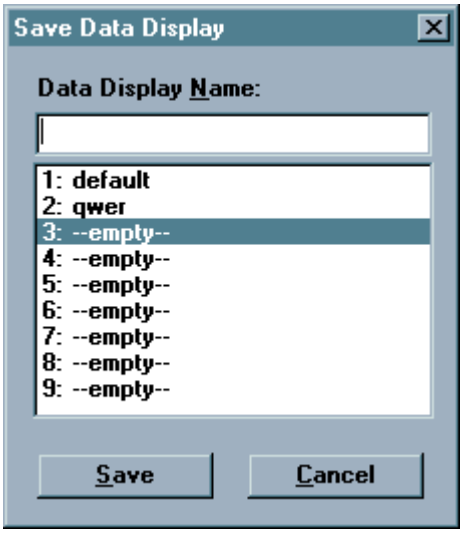
Toolbar:

Keys: CTRL+C

SAVE DATA DISPLAY

When opening a data file, you will probably want to look at the data in graph form. You may also want to rearrange the default graph by selecting or reordering parameters, zooming in to a portion of the graph, or even changing colors or changing fonts. You may sometimes choose to look at the data or a portion of it in table form. All of this work is done in the Data Display window.

This command allows you to save the settings and content of the Data Display window so that you can load it at another time and have it look exactly the same as when you saved it. This saved display is associated with the data file. Up to 9 data displays can be saved per data file. When you save a display you will be asked to give it a name in the following dialog box.

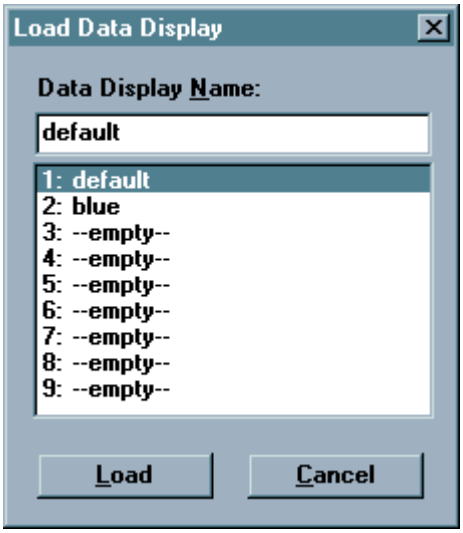


There must be an open data file for this command to be available. See also **Load Data Display.**

Shortcuts
Keys: CTRL+S

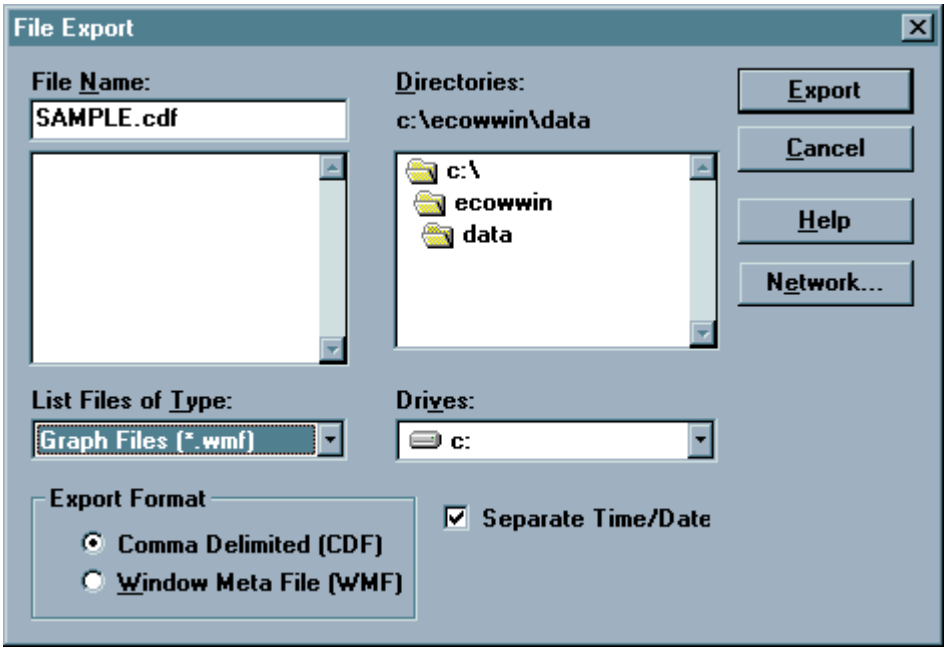
LOAD DATA DISPLAY

This command is only available when a data file is open. If you have previously used the **Save Data Display** command for the open data file, then you can load the saved display and have it look exactly the same as when you saved it. Saved displays are associated with the data file. You can have as many as nine saved displays for each data file. When loading a display you will be asked to choose from among the names of saved displays.



EXPORT

Use this command to send the current data to a file. Typically, some other program will read the file. You will see the following dialog box.



You may export the file in either of two forms: a WMF file, or a .CDF file.

WMF stands for Windows MetaFile and is a format that describes any image in a way that is independent of the program that generated the image. For example, you can generate a graph in EcoWatch, export it as a .WMF file and then import it into another Windows program.

CDF stands for Comma Delimited, sometimes referred to as a Comma and Quote Delimited File. This format is commonly used by spreadsheet and database programs. In this type of file, commas separate

individual data entries, quotation marks surround any text and no formatting or marking is performed on numbers. EcoWatch can also open files in CDF formats.

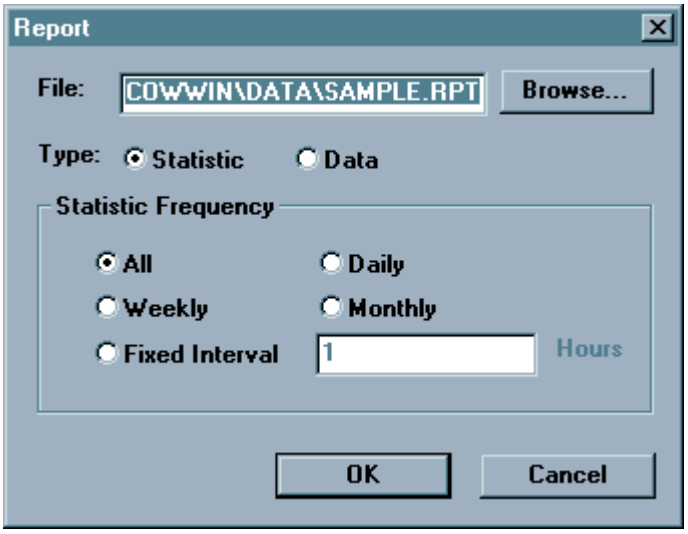
When the exported file is to be imported into a spreadsheet, it is sometimes convenient to reduce the number of data. Averaging them can easily do this. See **Change Parameter Attributes** for more information.

Shortcuts

Toolbar:

REPORT

Use this command to send data or statistics to an ASCII text file. The information is easy to read in this format. When choosing this command the following dialog box will appear.



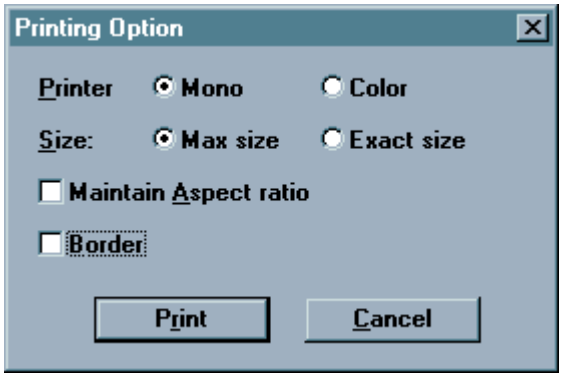
- You must enter a filename (under **File**; use the **Browse** button if needed). If you want to simply have a report **Type** listing the data, then click **Data**. If you want **Statistics** (minimum, maximum, average, and standard deviation), then the statistics frequency button applies.

- If you want to have **Daily** statistics, keep in mind that every day actually starts at midnight. It would be likely then that the first and last days would have very different statistics because they would only be partial days. **Daily, Weekly** and **Monthly** statistics behave similarly.

- When you click **OK**, EcoWatch will send the report to the specified file and open **Windows Notepad** where you can view and/or print the report. Note: Notepad can only open report files that are 64K or less in size. You can use the Windows Wordpad to open reports that are larger than 64K. Unless you change it, the report file will have the same location as your data file (.DAT) and has the same name with a .RPT file extension.

PRINT

Use this command to print a document. If a graph is selected, this command presents a **Print Option** dialog box with the options below. When a table is selected, a standard print window is



presented.

Shortcut

Toolbar:
Keys: CTRL + P

Printer
If you have a color printer, you can choose to print in **Color**. Otherwise you should choose **Mono** (black and white).

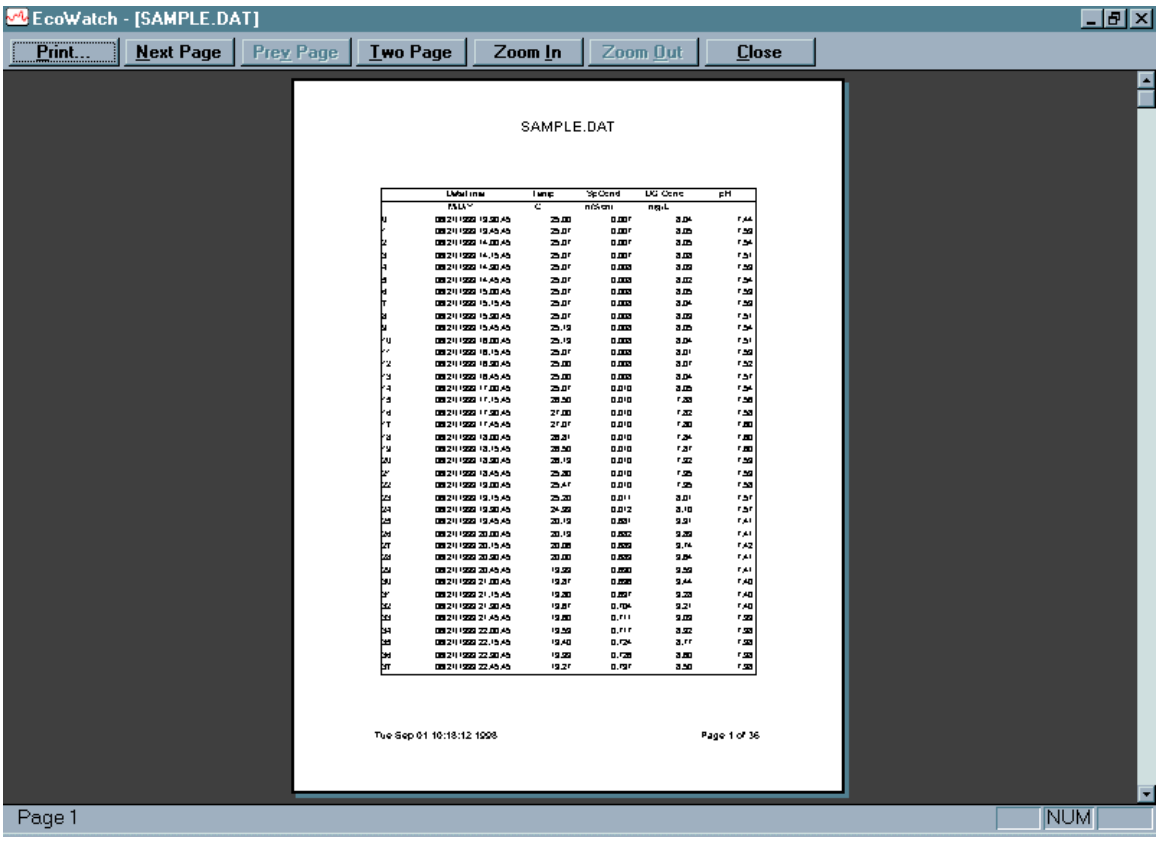
Size
If you choose **Max** size, then the program will size the graph so that it fits on one page. If you choose **Exact** size, then program will print the graph as close as possible to the size that is displayed.

Maintain Aspect Ratio
If you choose to maintain the aspect ratio, then the program will size the graph until either the height or the width is maximized and then leave the graph in the same height width ratio that is displayed.

Border
You can also choose whether or not to print a border.

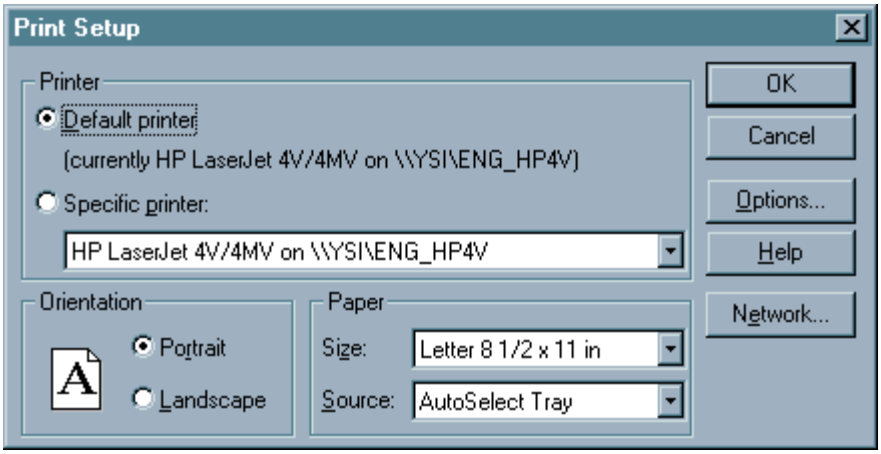
PRINT PREVIEW

This command allows the user to preview how the document will appear when it is printed. This command only works for data that is displayed in a table format, not when the data is in graph format.



PRINT SETUP

Use this command to select a printer and a printer connection. This command presents the **Print Setup** dialog box. The following options allow you to select the destination printer and its connection.

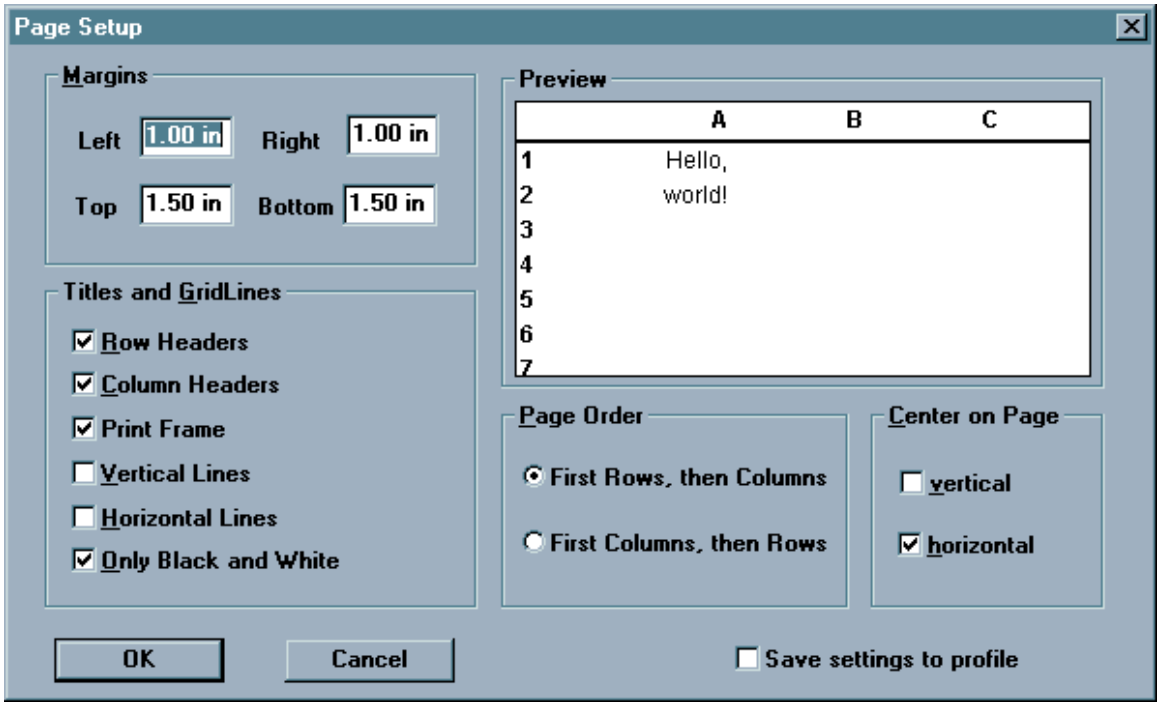


Printer Select the printer you want to use. Choose the **Default Printer**; or choose the **Specific Printer** option and select one of the current installed printers shown in

	the box. You install printers and configure ports using the Windows Control Panel.
Orientation	Choose **Portrait** or **Landscape**.
Paper Size	Select the size of paper that the document is to be printed on.
Paper Source	Some printers offer multiple trays for different paper sources. Specify the tray here.
Options	Displays a dialog box where you can make additional choices about printing, specific to the type of printer you have selected.
Network	Displays a dialog box that allows you to choose a printer if you are on a network.

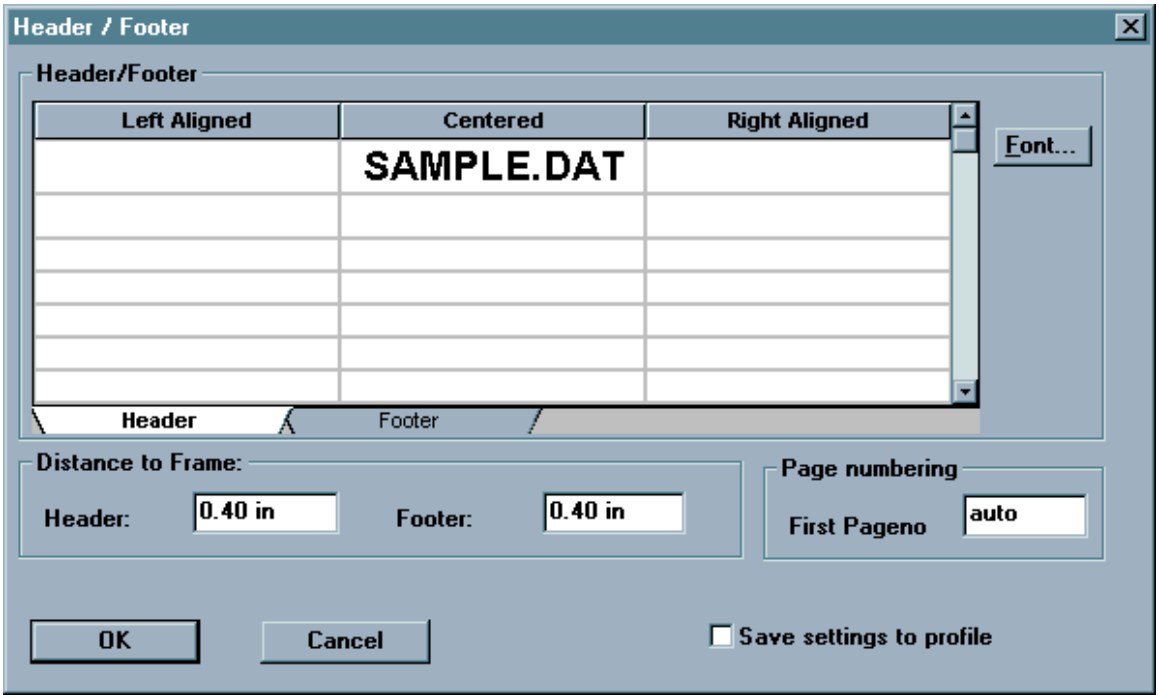
PAGE SETUP

Layout options for printable data tables may be specified. Page margins, table setup, page orientation, and page order are adjustable.



HEADER/FOOTER

Page headers and footers can be customized with respect to font and placement. Both the header and footer have separate tabs as shown below. Once the desired profile is created, it can be saved for use every time the particular data file is opened.



4.3.2 EDIT

The edit menu appears whenever a data file is opened in EcoWatch. It allows you to locate, format, and manage data.

COPY

Copies the selection to the clipboard. If a graph or table is active, then choosing this command will send its contents to the Windows clipboard so that it can be pasted into other programs. This is a normal method of transfer data between different Window programs.

Copying data to the clipboard replaces the contents previously stored there.

Shortcuts

Toolbar:
Keys: CTRL+C

PASTE

This command does not function in this version of EcoWatch.

REMOVE PARAMETERS

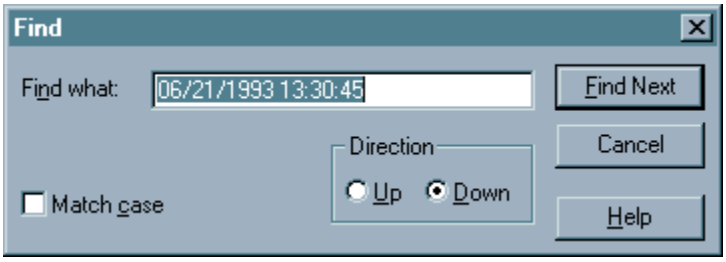
When entire column(s) of data is selected, including the heading(s), this command will remove the parameter(s) from both the data table and graph.

INSERT PARAMETER

Adds an additional parameter to the data table and graph. All available parameters that can be added are shown on a list.

FIND

Locates text within the selected parameter. Only one parameter may be searched at a time. A system beep indicates that there are no more occurrences of the desired text.



FIND AGAIN

Locates the text that was most recently searched for within the selected parameter. Only one parameter may be searched at a time.

4.3.3 VIEW

The **View** menu offers the following commands:

TOOLBAR

Use this command to display and hide the **Toolbar**, which includes buttons for some of the most common commands in EcoWatch, such as **File Open**. A check mark appears next to the menu item when the **Toolbar** is displayed.

Shortcut: To hide or display the Toolbar, choose **Toolbar** from the **View** menu.

See **Section 4.2.6, Using the Toolbar,** for a list of the toolbar icons and their functions.

STATUS BAR

Use this command to display and hide the **Status Bar**, which describes the action to be executed by the selected menu item or statuses of keyboard latch state. A check mark appears next to the menu item when the **Status Bar** is displayed.

The right areas of the status bar indicate which of the following keys are latched down:

CAP The Caps Lock key is latched down.

NUM	The Num Lock key is latched down.
SCRL	The Scroll Lock key is latched down

4-DIGIT YEAR

Use this command to toggle between a date with a two or four digit year on the graph and table.

GRAPH

Use this command to display and hide the **Graph** page when viewing a file. The graph page contains plots of data.

Shortcuts

Toolbar:

TABLE

Use this command to display and hide the **Table** page while viewing a data file.

Shortcuts

Toolbar:

GRID

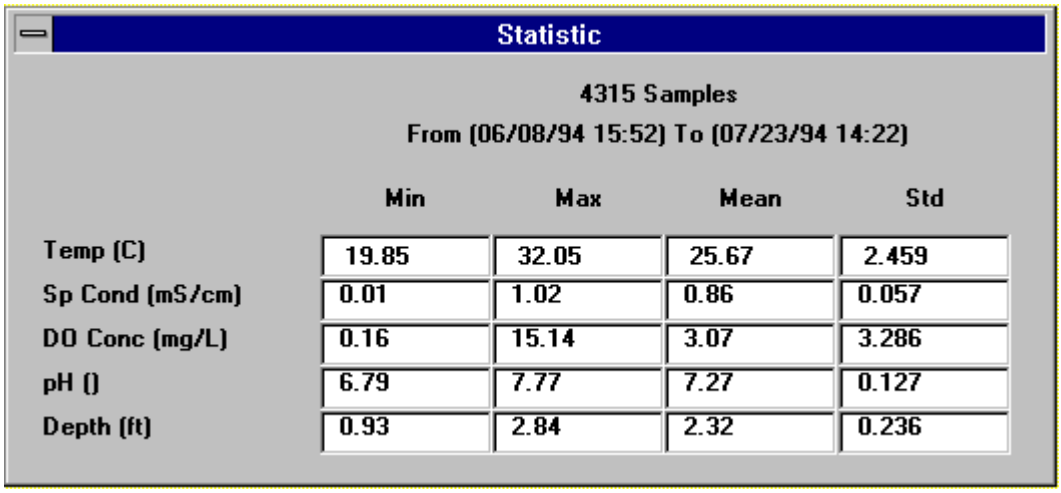
Turns on or off the gridlines on graphs.

MARKERS

Turns on or off data point markers on the graphs. For graphs with more than a few data points we recommend that **Markers** be left off.

STATISTIC

This command will display statistics for the current study. It will show the minimum, maximum, mean, and standard deviation for each of the current parameters. If you click on any minimum or maximum value, then a small box will appear showing the date and time when the minimum or maximum point occurred.

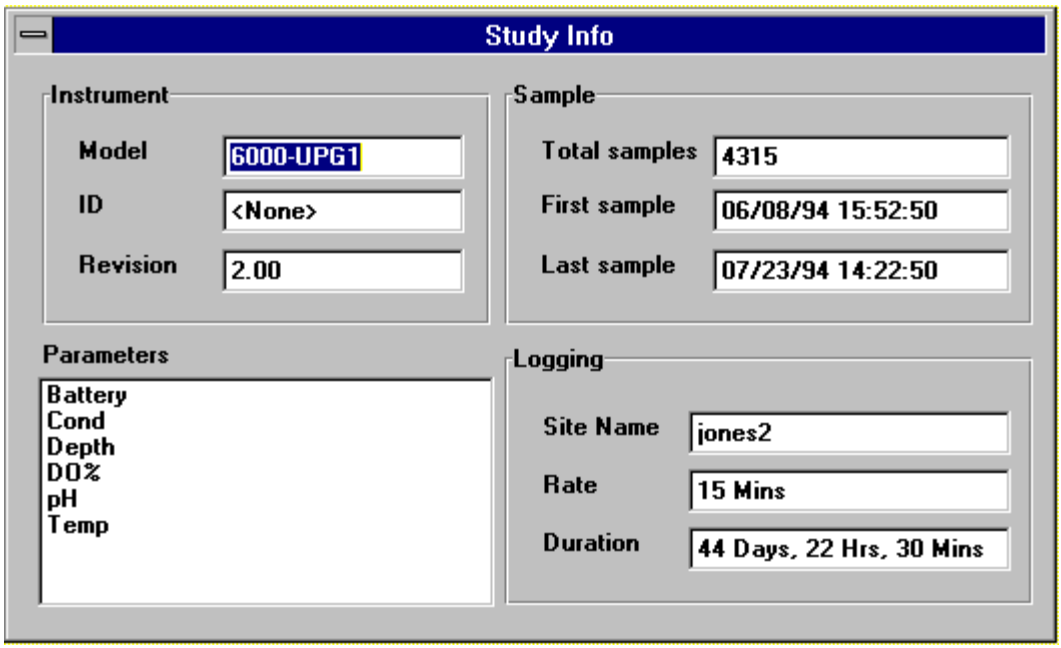


Shortcuts

Toolbar:

STUDY INFO

This command will display a dialog box describing the study. It will show the sonde type and serial number that was used to collect the data, the parameters available, the logging interval, and the beginning and ending times of the sample.



Shortcuts

Toolbar:

ZOOM IN

Enlarges graph or data table (whichever is currently active) by 20%.

Shortcuts

Toolbar:

ZOOM OUT

Reduces graph or data table (whichever is currently active) by 20%. If the graph already extends to both ends of the **Study Limits**, then it is not possible to zoom out any farther and this command will be dimmed.

Shortcuts

Toolbar:

UNZOOM

Displays the graph all the way to both ends of the **Study Limit** if a graph is selected. Displays the data table in default size, if a data table is selected.

Shortcuts

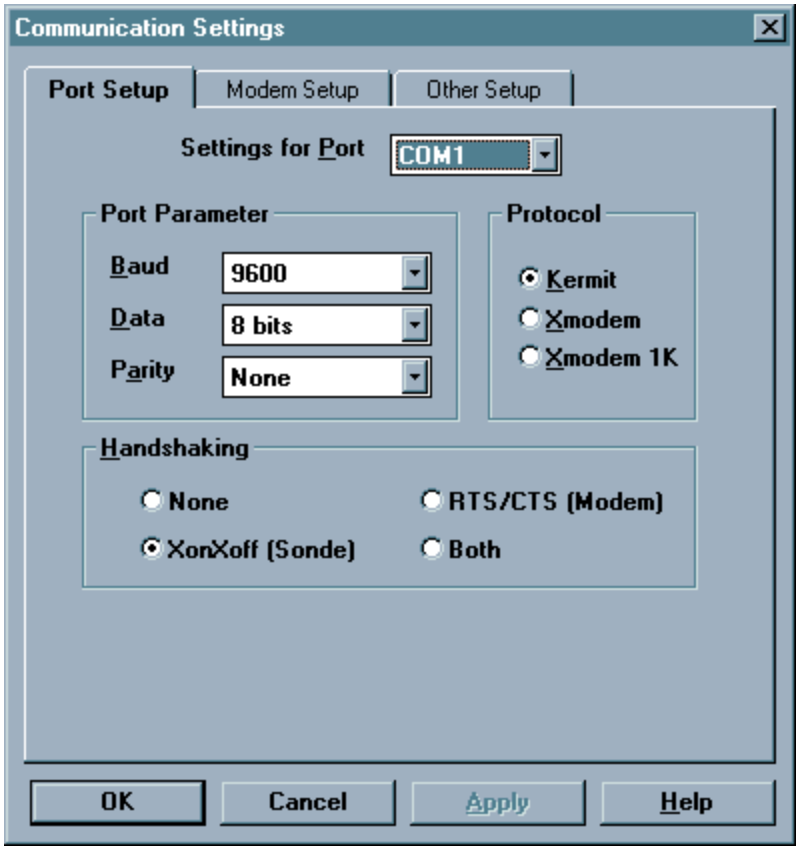
Toolbar:

4.3.4 COMM(UNICATION)

The **Comm** (Communications) menu commands let you control your communications settings with sondes, modems, and other devices. Several communication menu options are only available when a terminal window is opened.

SETTINGS

The **Communications Settings** dialog box is where you can configure the communications ports. The settings are organized into the following three tabs.



Port Setup

This is where you can set port parameters, file transfer protocol and handshaking for each of the ports that you will use.

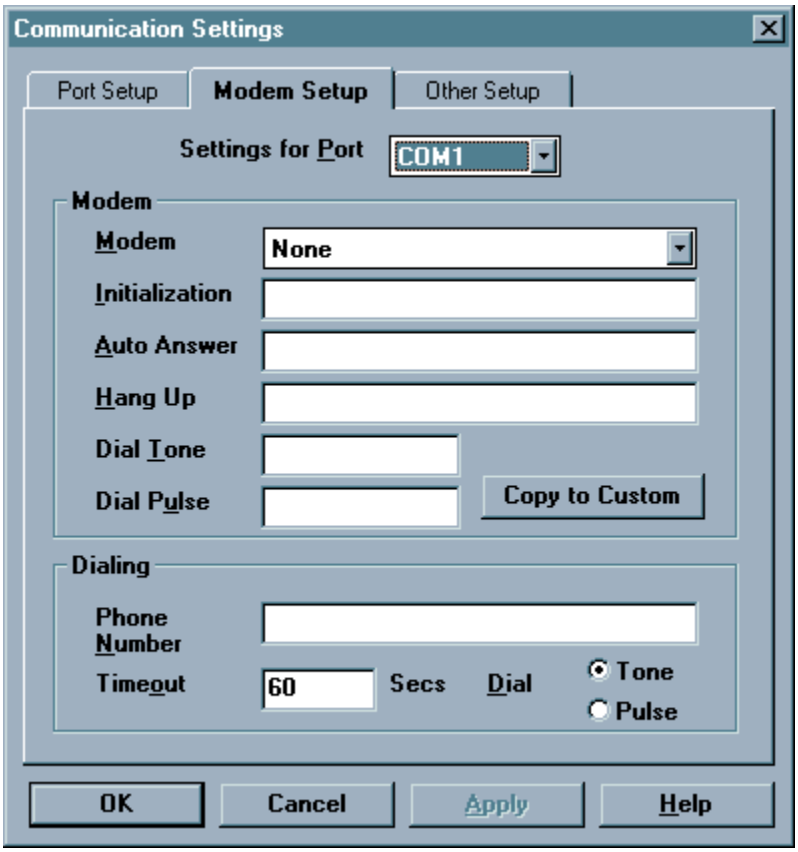
- **Port Parameter Setup**
  These include the most common settings for each communication port. These settings are **Baud Rate,** number of **Data** bits, and **Parity**. These settings must be identical to the settings on the device that is connected to the port. You may choose independent settings for each communication port.

- **Protocol**
  You may choose **Kermit**, **Xmodem** or **Xmodem 1K** protocol for file transfer through the communications port. 6820, 6920, 600R, 600XL, 600XLM and 6600 sondes use only **Kermit** protocol.

- **Handshaking**
  You may choose **Xon/Xoff**, or **RTS/CTS**, or **Both** or **None**. **Xon/Xoff** is often referred to as software handshaking and RTS/CTS as hardware handshaking. If you are using a YSI sonde select **Xon/Xoff**. Modems usually require **RTS/CTS**.

- **Modem Setup**
  This is where you enter the settings for your modem. Note that you can have several modems, each on separate COM ports, and each with its own settings.

If a modem is selected for a particular COM port, then every time that port is opened, EcoWatch will attempt to initialize a modem on that port. If the attempt fails, then EcoWatch will open a terminal window and you can communicate to that port with the computer keyboard. This can be very helpful in troubleshooting a connection to your modem or in determining exactly which settings work with your modem.



- **Modem**
  To setup a particular modem on your first try, select that modem from the **Modem** list. The only settings that you can edit are for the **Custom** modem.

  If your modem does not work, select "Hayes Compatible" modem. Those settings are quite common and might work for your modem. If neither approach works, then you will have to define your own settings. You will need the instruction manual for your modem. It should list all of the proper settings. Choose **Custom** from the **Modem** list and enter the settings for your modem.

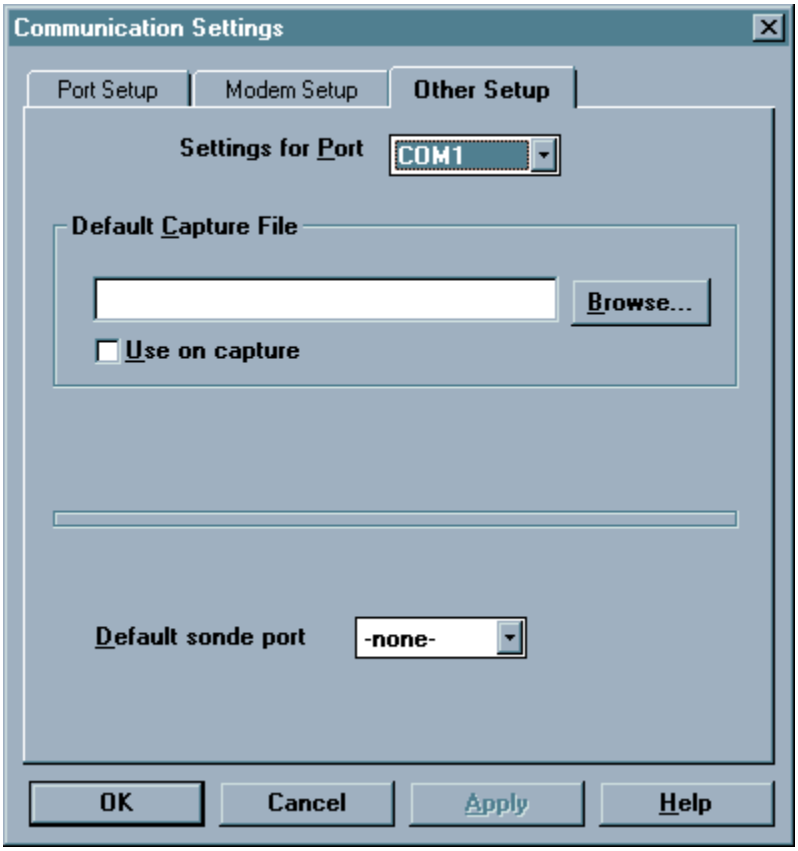
  The **Auto Answer** setting is included in the dialog for completeness. EcoWatch currently does not use **Auto Answer**.

  - **Copy to Custom**
    The **Copy to Custom** button is sometimes helpful in defining your own settings. If there is a similar modem, choose it from the list, and then click **Copy to Custom**. Choose **Custom** from the list and edit the settings. It transfers all modem settings from the currently selected modem to the "Custom" modem so you can modify the setting later.

- **Dialing**
  If there is no entry for **Phone Number**, then every time you choose an option that opens the COM port that connected to a modem, EcoWatch will ask you for a phone number. **Timeout** specifies how long in seconds EcoWatch will wait for the phone to answer.
  Use the **Dial** option to select **Tone** or **Pulse** dialing.

Other Setup

This is where you choose a default port for communicating with a sonde and default capture files for each sonde port. This tab addresses several COM port settings not covered on the other two tabs.



- **Default Capture File**
  While communicating to a sonde in terminal mode using the Sonde command, you may want to capture measurements to a file. You may type in a default file name in the accompanying text box.

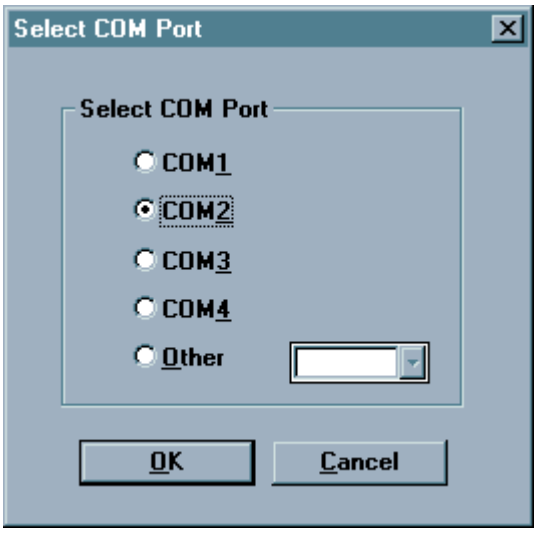
  If you specify a file name here and select the Use on Capture check box, then whenever you capture data, the program will write to that file without first asking you to confirm. If you specify a file but do not select the check box, then you will have to confirm that this is the file you wish to have your data written to before starting to capture.

- **Default Sonde Port**
  This refers to the COM port you will most commonly use to connect to your sonde. If you select a port here, EcoWatch will automatically use this port as the default COM port when you use the Sonde command.

The **Apply** button in the bottom of this dialog box is not used in EcoWatch.

SONDE

This command opens a terminal window for communicating with a sonde. From the terminal window you can communicate to a sonde using the sonde menus. Unless you have chosen a default sonde port in the **Communications Settings** dialog box the following dialog box will appear asking you which COM port to use.



Shortcuts

Toolbar:

TERMINAL

Opens a new terminal window for communicating with any compatible RS-232 devices.

FONT/COLOR

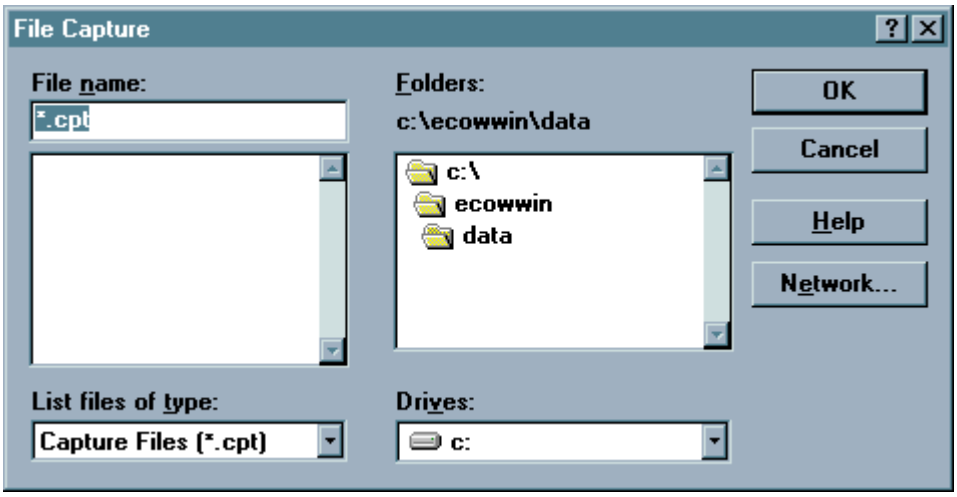
Adjust font color, size, and style for any text that appears in the terminal window.

BACKGROUND COLOR

Adjust the background color of the terminal window.

CAPTURE

Turns COM port capture **On** or **Off**. This is typically used while communicating with a sonde that is taking measurements. Capture will send all communications received on the COM port to a file. After selecting the command, a dialog box will appear for selecting the name of the file to use. If “Use default capture” file was checked in Communications Settings, EcoWatch will not display this dialog.



A common example is using a sonde in **Run Mode**. The sonde is simply taking readings and sending them to the COM port. If you want to keep a record of these readings, then a simple way to do so is to turn **Capture** on. When you are finished, run the **Capture** command again to turn it off.

FILE UPLOAD

Use this command to upload files from any device that uses **Xmodem** file transfer protocol. First initiate the upload from the device, then choose this command. This command is enabled only when the **Xmodem** or Xmodem 1K protocol has been selected in **Port Setup**.

DIAL MODEM

If you have specified a default phone number in the **Modem** tab of the communications **Settings** dialog box, then this command will call that number. If you have not specified a default number, then you will be asked for a number.

HANG-UP MODEM

Hangs up phone and halts communication with the modem.

SEND ASCII FILE

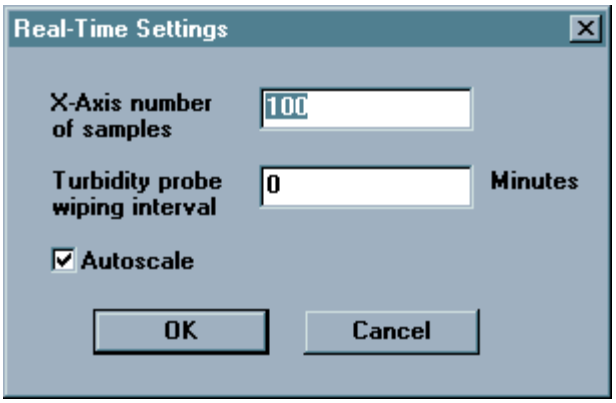
Sends a file in to the device connected to the terminal using plain ASCII protocol. No handshaking or error correction is involved.

SEND XMODEM FILE

Sends a file to the device connected to the terminal using **XModem** protocol.

4.3.5 REAL-TIME

The **Real-time** menu offers the following commands that allow you to control how your data will be presented.



SETTINGS

This command is only active when there is a real-time window open. This command takes you to the **Real-time Settings dialog** where you can set the length of the x-axis.

In the Real-Time Settings box you will set the number of samples graphed across the axis. (The interval between samples is set in the sonde using the sonde menus.) After the graph is full, each new data point will cause the trace to scroll left so that you see only the most recent set of measurements.

If you have a YSI 6026 or 6136 turbidity, 6025 chlorophyll, or 6130 rhodamine WT probe with a wiper, then you may want to clean the optics periodically. Set that interval in this dialog.

Autoscaling will keep the trace comfortably on the graph as the measurement changes.

To **Manually Scale** a graph; double-click on its Y-axis labels. The Graph Y-Axis box will come up where you can set the scale. Note that you can manually set the scale for some parameters and autoscale others. When the autoscale box is checked, the high and low limits will be unavailable. See also the **Autoscale** command in the **Graph** menu.

NEW

Choose this to start a new real time study.

OPEN

Choose this to open a previous real time study.

CLOSE

Choose this to close a real time study.
Two files are formed every time a real time study is started. You will choose a .RT file that will store colors, scaling information, number of parameters and other information useful to the program. At the same time, the program starts another file with the same name but a .DAT extension for the actual measurements that are taken during the study.

4.3.6 GRAPH

ZOOM WINDOW

Enlarges a section of the graph. The pointer will change to a magnifying glass and then you can click and drag on the graph to indicate the section you want to view. This command stays active until you execute it again.

Shortcuts

Toolbar:

CENTER SCROLL

Centers graph at the mouse cursor. The pointer will change to a bullseye. Clicking anywhere on the graph will cause that point to be moved to the center. This command stays active until you execute it again.

Shortcuts

Toolbar:

LIMIT DATA SET

This command limits the amount of data being processed. If you are not presently interested in portions of the graph or table at the beginning or end of the study, you may want to use this command to indicate only that portion that you are interested in. The program will have fewer data points to handle and will respond to your commands quicker. Executing this command when modifying a graph will change the pointer to a vertical arrow. Click once on the left end of that part of the graph that you want and then click again at the right end. This command stays active until you execute it again.

To limit the data in a table, move the pointer to the far left of the table into the row numbers area and highlight from the desired cutoff point to the beginning or end of the data set, whichever is desired. Then select the **Limit Data Set** option from the graph menu or use the toolbar shortcut.

To undo the limits choose **Cancel Limits** below. Alternately, you may remove the limits on a graph by executing this command backwards. That is, click anywhere on the right side of the graph first, and then click anywhere on the left side. The limits will be moved to the ends of the file.

Shortcuts

Toolbar:

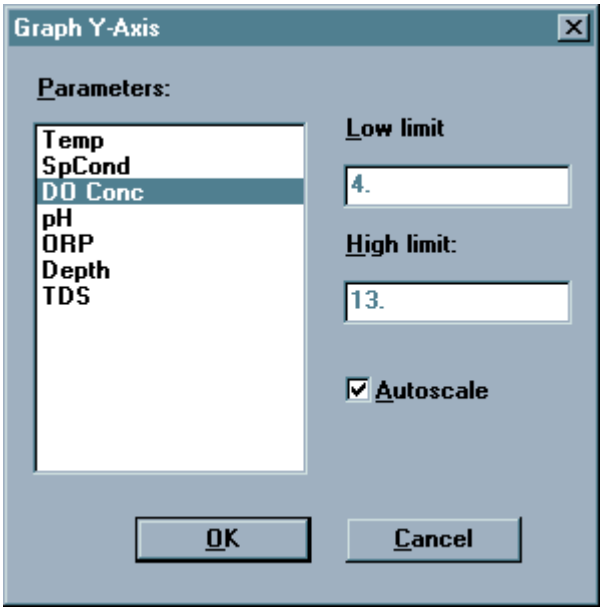
AUTOSCALE

Sets the scale of each parameter so that the minimum and maximum points fit comfortably on the graph.

MANUAL SCALE

Takes you to the **Graph Y-Axis** dialog box where you can set the scale for each parameter.

Graph Y-axis dialog box
To manually scale a graph, double click on its Y-axis labels. A dialog will come up where you can set the scale. Note that you can manually set the scale for some parameters and autoscale others. When the autoscale box is checked, the high and low limits will be dimmed. See also the Autoscale command in the Graph menu.



.

REDRAW

If part of a graph is not displayed it could be because your window is sized too small to display it or because you have just returned to EcoWatch from some other application. Maximizing the window and choosing this command should display your graph correctly

Shortcuts

Toolbar:

CANCEL LIMITS

Choose this command to cancel the limits set by the **Limit Data Set** command.

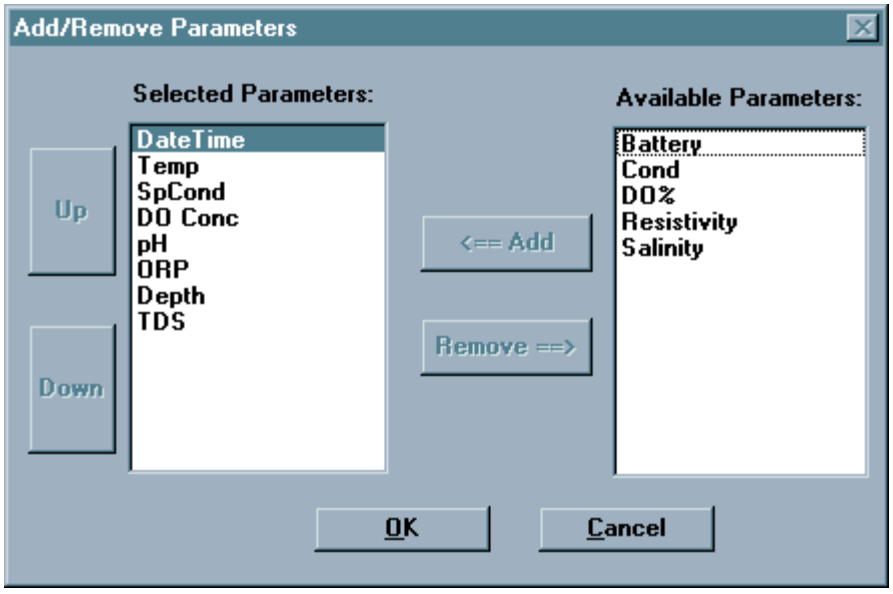
4.3.7 SETUP

PARAMETER

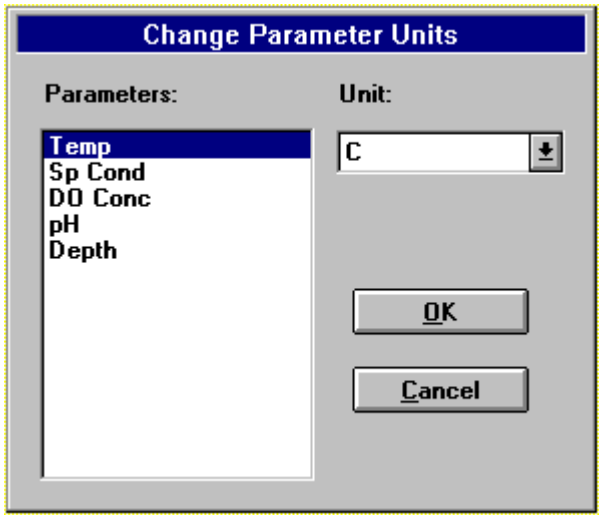
Lets you select which parameters you want to analyze and how they will appear.

Add/Remove
There are two lists, **Selected Parameters** and **Available Parameters**. If, for example, you wish to graph another parameter, you must highlight it on the **Available Parameter** list and then click the Add button to move it over to the **Selected Parameters** list.
This is also where you decide the order in which the parameters will appear in both the table and the graphs. If you choose to have two traces per graph, then the first graph will have the first and second parameters on this list, the second graph will have the third and fourth parameters and so forth. The parameters will appear in the **Selected Parameters** list in the order that they were added. To rearrange the order, highlight the parameter you wish to move and then use the up and down buttons to move it to the desired spot in the order.

The **TSS parameter** (only available if your sonde has a Turbidity sensor) is a parameter that is not part of your original collected data. TSS is calculated by EcoWatch, which uses the Turbidity data and a set of correlation points that you enter. When you add TSS, a TSS calibration window will popup and prompt you for a set of correlation points. For more information see **Calibrate TSS**.

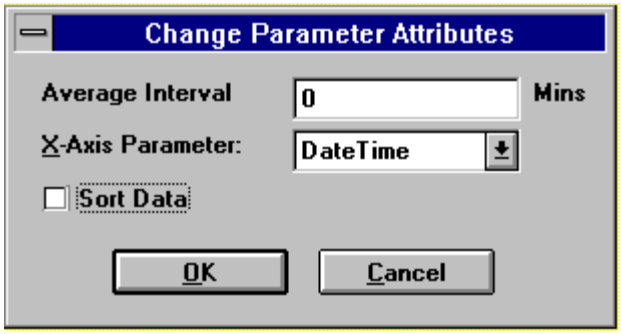


Units
Select the units for any parameter. It will take you to the **Change Parameter Units** dialog box. You may choose the units for each of the selected parameters. Many parameters have only one possible choice of units. DO concentration, for example; can only be expressed in mg/L. pH has no units at all.



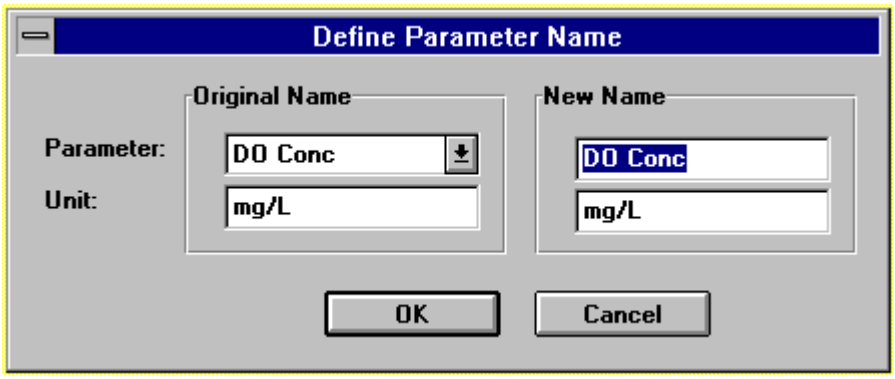
Attributes
This command takes you to the **Change Parameter Attributes** dialog box where you have access to two powerful features. You can choose to display an average of your data, or graph the data with some parameter other than time for the x-axis. The most common use for this latter feature is to graph temperature and DO versus depth. Other combinations are possible. You may choose to average the data before it is graphed. An interval of 0 will cause there to be no averaging at all. The larger the averaging interval, the more points will be used in each average. For example, if you acquired data every 15 minutes and you set the average interval to 60 minutes, each set of four points will be averaged and then plotted as a single point. This feature will not only smooth a graph, but will also reduce the amount of data exported that is sometimes convenient when exporting to a spreadsheet.

The x-axis parameter is normally **Time**, but you can choose any parameter you like. By default, data files are sorted by increasing time. If you have chosen another parameter for the x-axis, then you may want to have the data sorted before graphing it.



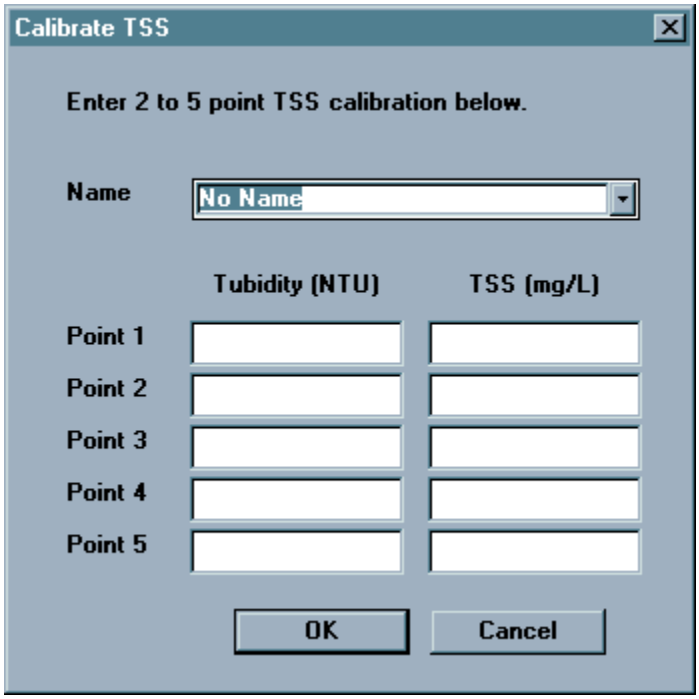
Change name
This command takes you to the **Define Parameter Name** dialog box where you may change the default names of the parameters.

This dialog is intended to make changes like "degrees Celsius" to "degrees C". If you change "degrees Celsius" to "degrees Fahrenheit", then the data displayed will be in degrees Celsius even though the graph says "degrees Fahrenheit." To change the units for that parameter, use the **Change Parameter Units** dialog box.



Calibrate TSS

TSS is an abbreviation for Total Suspended Solids. TSS is a unit derived from a Turbidity (NTU) measurement and correlated TSS-NTU measurements. The Calibrate TSS feature is only used if the TSS parameter has been added to the current data file using **Add/Remove Parameters**. This command opens the TSS Calibration window and allows calibration adjustment.



How do I add TSS to my data file?

You must have a data set that includes Turbidity data points.

It is also common to use a 0 to 0 correlation as a base point in these measurements. This can be used as the first correlation point. You need to establish a correlation between your Turbidity reading and a TSS value. This is done by taking a sample and noting its Turbidity in NTU's. Then run a lab analysis to obtain a total suspended solids reading. You have now determined one correlation point.

Once you have at least two correlation points, you have established a linear correlation between the two measurements. EcoWatch allows you to enter up to five correlation

points. The more correlation points you have, the higher that your accuracy will be.

To add the TSS parameter to your data file, go to the **Setup** menu. Choose **Parameters**, then **Add/Remove**. Select the **TSS** parameter and click the **Add** button. The Calibrate TSS window will appear.

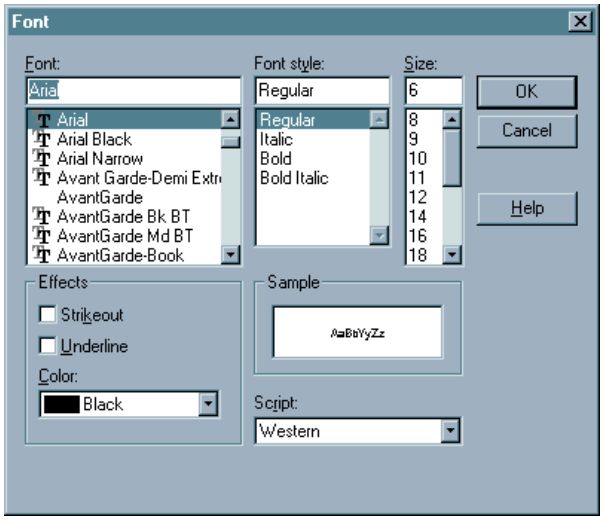
Name the file for identification in the future. Multiple calibration files may be created. Any previously created calibration files will be located in the drop-down name list box.

Once you have entered the desired number of correlation points, click **OK**. EcoWatch will calculate the TSS values by doing a linear interpolation of the Turbidity (NTU) data and the correlation chart .

GRAPH

The **Setup** menu, **Graph** submenu has the following commands:

Font/Color
Goes to the **Font Dialog Box** where you can change the font and color of text that appears in the graph.



- **Font**
  Type or select a font name. EcoWatch lists the fonts available with the current printer driver and additional fonts installed in your system.

- **Font Style**
  Select a font style. To use the default type style for a given font, select Regular.

- **Size**
  Type or select a font size. The sizes available depend on the printer and the selected font. If the size you type is not available on the current printer, EcoWatch chooses the closest available size.

- **Effects**
  Choosing **Strikeout** will draw a line through all text in the table. Choosing underline will underline the text.

- **Color**

Type or select one of the 16 predefined colors. To display color, you must have a color monitor; to print color, you must have a color plotter or a color printer.

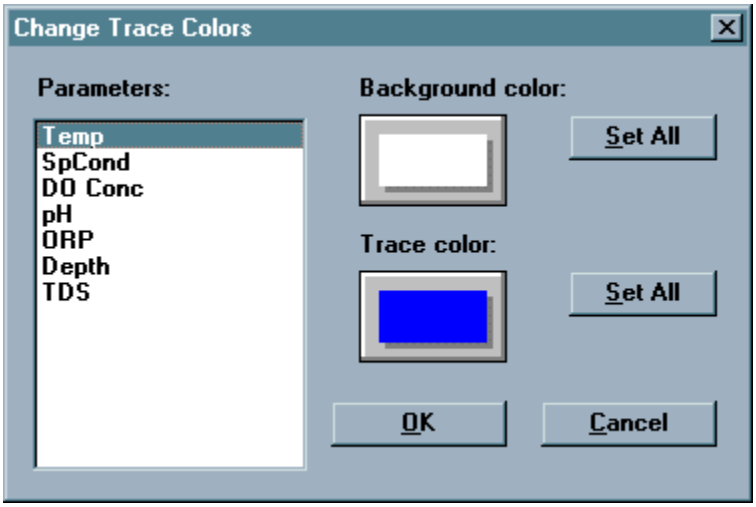
- **Sample**
  Shows the effects of the formatting you specify before you apply it to the document.

Page Color

Goes to the **Color Dialog Box** where you can change the color of the graph page. This is the background for all of the graphs rather than the background for each individual graph that is set with the next command.

Trace Color

Goes to the **Change Trace Color** dialog box where you can change the color of the trace and the background for each of the individual graphs. For setting the background color for all graphs, see the previous command.

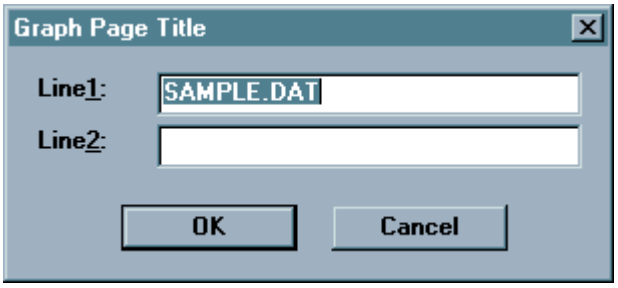


Note that there are two color buttons, one for the trace color and the other for the background color. Clicking on either of these buttons will take you to the **Color** dialog box where you can change the color.

Use the **Set All buttons** to quickly set all traces or backgrounds to the same color.

Page Title

This is where you can enter a title for the graph. The title may have one or two lines.



1 Trace per Graph

Choose this to have just one parameter on each graph.

2 Traces per Graph

Choose this to have two parameters on each graph.

TABLE

If there is no table, then the commands on this submenu will be unavailable. The Table submenu offers the following commands:

Font/Color

Goes to the Font Dialog Box where you can change the font and color of text that appears in the table.

Page Color

Goes to the Color Dialog Box where you can change the color of the table background color. That is the part of the table where the readings appear.

Highlight Color

Goes to the Color Dialog Box where you can change the color of the table highlight color. That is the part of the table where the reading units appear.

SET DEFAULT TEMPLATE

This option allows you to select display parameters for your data when you initially open a file in EcoWatch. Display parameters include background and trace colors on your graph, which parameters are displayed, parameter ordering, parameter units, and scaling of those parameters (either manual or automatic). The first time you use EcoWatch with a data file, graphing will proceed according to the default settings present in EcoWatch. For example, graph backgrounds will all be black, traces will be plotted each with a different color, all parameters will be auto-scaled, and if your sonde measures conductivity and dissolved oxygen, EcoWatch will display specific conductance in mS/cm and dissolved oxygen in mg/L. You can change the default settings by using **Set Default Template.**

1 - Open a data file and observe the presentation of the data in graphic and tabular form.

2 - You can change the background and trace colors by going into the **Graph** and/or **Table submenus** of the **Setup Menu**.

3 - You can add or remove parameters by going into the **Parameter submenu** of the **Setup Menu**.

4 - You can change the units of the displayed parameters by going into the Parameter submenu of the Setup Menu.

5 - You can change the order of the parameters by going into the **Add/Remove Parameters dialog box** in the **Parameter submenu** of the **Setup Menu**.

6 - You can set the scaling options for your data by double-clicking on the Y-axis of the graph and using the **Graph Y-Axis dialog box** to set the scales.

7 - After setting the display parameters enter the **Setup Menu** and choose **Set Default Template**. Now every data file that you initially open will use the display parameters that you have chosen. If you want to delete your template, enter the **Setup Menu** and choose **Clear Default Template**.

CLEAR DEFAULT TEMPLATE

This command will eliminate a default template that has been saved. With no default template, all new EcoWatch files open in whatever form they were saved in.

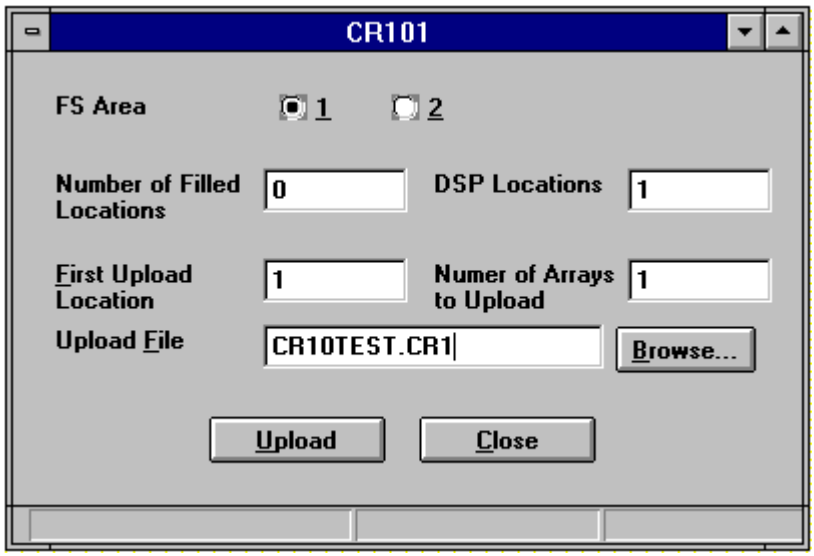
4.3.8 APPL(ICATIONS)

The **Appl** menu is the link to other Application programs that can be used with EcoWatch.
For Help using a GIS software, consult the menu that came with the GIS system.

To upload from a Campbell Scientific CR10 Logger, first connect the logger to a COM port using a Campbell Scientific SC32A Adapter. Set the port for 9600 Baud, 8 data bits, no parity and Xon/Xoff handshaking. Then from the EcoWatch **Appl** menu, select **CR10 Upload.** The dialog box below will appear.

The items Number of Filled Locations and DSP Locations are information from the logger that you cannot change. FS Area, First Upload Location, and Number of Arrays to Upload are fields that you must enter. Refer to your CR10 manual for instructions.

Select a destination file (under Upload File; use the Browse button as needed) and click Upload.



4.3.9 WINDOW

The Window menu offers the following commands that enable you to arrange multiple views of multiple documents in the application window:

CASCADE

Use this command to arrange multiple opened windows in an overlapped fashion

TILE HORIZONTAL

Use this command to vertically arrange multiple opened windows in non-overlapped horizontal tiles.

TILE VERTICAL

Use this command to arrange multiple opened windows side by side.

ARRANGE ICONS

Use this command to arrange the icons for minimized windows at the bottom of the main EcoWatch window. If there is an open document window at the bottom of the main window, then some or all of the icons may not be visible because they will be underneath this document window.

WINDOW 1, 2...

EcoWatch displays a list of currently open document windows at the bottom of the Window menu. A check mark appears in front of the document name of the active window. Choose a document from this list to make its window active.

4.3.10 HELP

The Help menu offers the following commands, which provide you assistance with this application:

CONTENTS

Offers you a list of the available Help topics.

USING HELP

Use this command for instructions about using Help.

TECHNICAL SUPPORT

YSI Technical support phone number.

ABOUT

Displays the version number of this application.

SECTION 5 PRINCIPLES OF OPERATION

5.1 CONDUCTIVITY

The sondes utilize a cell with four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milli-Siemens (millimhos). To convert this value to a conductivity value in milli-Siemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the sonde conductivity cell is approximately 5.0/cm. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed. Solutions with conductivities of 1.00, 10.0, 50.0, and 100.0 mS/cm, which have been prepared in accordance with recommendation 56-1981 of the Organization International De Metrologie Legale (OIML), are available from YSI. The instrument output is in mS/cm or uS/cm for both conductivity and specific conductance. The multiplication of cell constant times conductance is carried out automatically by the software.

CALIBRATION AND EFFECT OF TEMPERATURE

The conductivity of solutions of ionic species is highly dependent on temperature, varying as much as 3% for each change of one degree Celsius (temperature coefficient = 3%/°C). In addition, the temperature coefficient itself varies with the nature of the ionic species present.

Because the exact composition of a natural media is usually not known, it is best to report a conductivity at a particular temperature, e.g. 20.2 mS/cm at 14 ^{o}C. However, in many cases, it is also useful to compensate for the temperature dependence in order to determine at a glance if gross changes are occurring in the ionic content of the medium over time. For this reason, the sonde software also allows the user to output conductivity data in either raw or temperature compensated form. If Conductivity is selected, values of conductivity that are *NOT* compensated for temperature are output to the report. If Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C. The calculation is carried out as in equation (1) below, using a temperature coefficient of 1.91%/°C (TC = 0.0191):

$$\text{Specific Conductance } (25^{o}\text{C}) = \frac{\text{Conductivity}}{1 + TC * (T - 25)}$$

As noted above, unless the solution being measured consists of pure KCl in water, this temperature compensated value will be somewhat inaccurate, but the equation with a value of TC = 0.0191 will provide a close approximation for seawater and for solutions of many common salts such as NaCl and NH_4Cl.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - When filling the calibration vessel prior to performing the calibration procedure, make certain that the level of calibrant standard is high enough in the calibration cup or beaker to cover the entire conductivity cell.

2 - After placing the sonde in the calibration solution, agitate the sonde to remove any bubbles in the conductivity cell.

3 - During calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The readings after calibration are only as good as the calibration itself.

4 - Perform sensor calibration at a temperature as close to 25°C as possible. This will minimize any temperature compensation error.

5- The 6560 YSI 6-series conductivity system is extremely linear and therefore the sensor will be accurate within its 0.5% accuracy specification when calibrated anywhere in the range. Thus, there is normally no need to calibrate with low conductivity standards when making measurements in fresh water or high conductivity standards when making measurements in brackish or sea water. Low conductivity standards are very susceptible to contamination and their use is not recommended unless extra care is taken to rinse the calibration vessel and probe compartment with the standard prior to actually calibrating. For most applications, YSI recommends calibration using a mid-range calibration standard of approximately 10,000 uS/cm such as YSI 3163 Calibrator Solution which is available in quart bottles. For special applications or for users who insist on calibrating at values near that of the water to be monitored, YSI does offer standards of higher and lower conductivities – see **Appendix C Accessories and Calibration Reagents**.

5.2 SALINITY

Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C. However, the unitless salinity values are very close to those determined by the previously used method where the mass of dissolved salts in a given mass of water (parts per thousand) was reported. Hence, the designation "ppt" is reported by the instrument to provide a more conventional output.

5.3 TOTAL DISSOLVED SOLIDS (TDS)

The electrical conductivity of environmental water is due to the presence of dissolved ionic species. Thus, the magnitude of the conductivity (or specific conductance) value can be used as a rough estimate of amount (in g/L) of these ionic compounds which are present. The 6-series software provides a conversion from specific conductance to total dissolved solids (TDS) by the use of a simple multiplier. However, this multiplier is highly dependent on the nature of the ionic species present. To be assured of even moderate accuracy for the conversion, the user must determine this multiplier for the water at the site of interest. Use the following protocol to determine the conversion factor:

1. Determine the specific conductance of a water sample from the site;
2. Filter a portion of water from the site;
3. Completely evaporate the water from a carefully measured volume of the filtered sample to yield a dry solid;
4. Accurately weigh the remaining solid;
5. Divide the weight of the solid (in grams) by the volume of water used (in liters) to yield the TDS value in g/L for this site; Divide the TDS value in g/L by the specific conductance of the water in mS/cm to yield the conversion multiplier. Be certain to use the correct units.
6. Enter the determined constant into the sonde software from the Advanced|Sensor menu to view the correct TDS values from a computer/sonde interface.

CAUTION: The default value (0.65) for conversion of specific conductance in mS/cm to TDS in g/L which is resident in the Advanced|Sensor menu of the software is only useful for a gross estimate of the TDS. As noted above, to attain any degree of accuracy for TDS, the user must determine the conversion factor empirically. Even then, if the nature of the ionic species at the site changes during an unattended study or between sampling studies, the TDS values will be in error. It is important to recognize that,

generally speaking, TDS cannot be calculated accurately from specific conductance unless the make-up of the chemical species in the water remains constant.

NOTE: EcoWatch for Windows contains a conversion factor of 0.65 for conversion of specific conductance in mS/cm to TDS in g/L. However, unlike the sonde software, this constant cannot be varied in EcoWatch. Thus, to calculate TDS from data resident in an EcoWatch file, the user should export the specific conductance readings to a spreadsheet and carry out the calculation there using the formula:

TDS in g/L = (Sp. Cond in mS/cm) x (User-Derived Constant)

5.4 OXIDATION REDUCTION POTENTIAL (ORP)

The sondes determine the Oxidation Reduction Potential (ORP) of the media by measuring the difference in potential between an electrode which is relatively chemically inert and a reference electrode. To measure ORP with a sonde, a combination pH/ORP probe must be in place in the sonde bulkhead and ORP must be accessed via the ISE2 channel of the sonde. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

CALIBRATION AND EFFECT OF TEMPERATURE

Calibration may not be required for the ORP sensor of the sonde when it is new. However, older probes that have been deployed extensively may show some deviation from the theoretical ORP value. This deviation is usually due to a change in the concentration of the KCl in the reference electrode gel. To determine whether the sensor is functioning correctly, place the ORP probe in 3682 Zobell solution and monitor the millivolt reading. If the probe is functioning within specifications, the ORP reading should be within the range of 221-241 at normal ambient temperature. If the reading is outside of this range, the probe can be calibrated to the correct value (231 mV at 25°C) using the calibration procedure outlined in **Section 2.6.1, Calibration.**

ORP readings for the same solution can vary up to 100 mv depending on the temperature. However, no standard compensation algorithms exist for this parameter. Be sure to take this factor into account when reporting ORP values and checking sensor calibration. For Zobell solution, consult the following chart:

TEMPERATURE, CELSIUS	ZOBELL SOLUTION VALUE, MV
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

MEASUREMENT AND CALIBRATION PRECAUTIONS

1 - Instructions for preparation of ORP calibrator solutions (including Zobell reagent) can be found in Section 2580 A. of *Standard Methods for the Examination of Water and Wastewater*. Alternatively, the Zobell solution is available from YSI.

2 – Reagants to confirm ORP sensitivity are available. Contact YSI Technical Support for ordering information.

3 - ORP readings usually stabilize much more rapidly in standards (e.g., Zobell solution) than in most environmental water. Be certain to consider this factor when determining ORP in field studies.

4 - Clean and store the pH/ORP sensor by following the instructions in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.5 pH

The sondes employ a field replaceable pH electrode for the determination of hydrogen ion concentration. The probe is a combination electrode consisting of a proton selective glass reservoir filled with buffer at approximately pH 7 and a Ag/AgCl reference electrode that utilizes electrolyte that is gelled. A silver wire coated with AgCl is immersed in the buffer reservoir. Protons (H^+ ions) on both sides of the glass (media and buffer reservoir) selectively interact with the glass, setting up a potential gradient across the glass membrane. Since the hydrogen ion concentration in the internal buffer solution is invariant, this potential difference, determined relative to the Ag/AgCl reference electrode, is proportional to the pH of the media. The pH system of the 600R utilizes individual glass sensing and reference electrodes, but the operating principle is the same.

YSI offers three styles of pH and pH/ORP relative to the glass portion of the probe – flat-, bulb-, and hemisphere-type. The bulb-type sensors (6561, 6565, and 6566) use lower impedance glass and therefore are more stable in laboratory applications and calibration when in the presence of static. The flat-type sensors have higher impedance glass and so may show some jumpiness during laboratory operations, including calibration, unless the user avoids touching the sonde and stays out of close proximity to the instrument. The advantages of the flat-type glass sensors are that (a) they are much less susceptible to breakage than their bulb-type analogs and (b) they are more readily cleaned in long term field studies when using the auxiliary brush of the 6600EDS V2-2 sonde. Users should consider these factors when deciding which YSI pH or pH/ORP sensor to purchase.

Our testing of the 6561, 6561FG, 6565, 6565FG, 6566 pH or pH/ORP sensors, 6569 pH/ORP, 6579 pH, and the 600R/600QS pH/ORP system indicates that they should provide long life, good response time, and accurate readings in most environmental waters, including freshwater of low ionic strength. Thus, no special sensor is required (nor offered) for water of low conductivity.

CALIBRATION AND EFFECT OF TEMPERATURE

The software of the sondes calculates pH from the established linear relationship between pH and the millivolt output as defined by a variation of the Nernst equation:

$E = E_o + \frac{2.3RT}{nF} * pH$ where E = millivolts output

E_o = a constant associated with the reference electrode

T = temperature of measurement in degrees Kelvin

R, n, and F are invariant constants

Thus, in simplified ***y = mx + b*** form, it is (mv output) = (slope)x(pH) + (intercept). In order to quantify this simple relationship, the instrument must be calibrated properly using commercially available buffers of known pH values. In this procedure, the millivolt values for two standard buffer solutions are experimentally established and used by the sonde software to calculate the slope and intercept of the plot of millivolts vs. pH. Once this calibration procedure has been carried out, the millivolt output of the probe in any media can readily be converted by the sonde software into a pH value, *as long as the calibration and the reading are carried out at the same temperature.* This last qualifier is almost never met in actual environmental measurements since temperatures can vary several degrees during a deployment simply from a diurnal cycle. Thus, a mechanism must be in place to compensate for temperature or, in other words, to accurately convert the slope and intercept of the plot of pH vs. millivolts established at T_c (temperature of calibration) into a slope and intercept at T_m (temperature of measurement). Fortunately, the Nernst equation provides a basis for this conversion.

According to the Nernst equation as shown above, the slope of the plot of pH vs. millivolts is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mv/pH unit at 298 K (25 C), then the slope of the plot at 313 K (40 C) must be (313/298) * 59 = 62 mv/pH unit. At 283 K (10 C), the slope is calculated to be 56 mv/pH unit ((283/298) * 59). Determination of the slope of pH vs. mv plots at temperatures different from T_c is thus relatively simple. In order to establish the intercept of the new plot, the point where plots of pH vs. mv at different temperatures intersect (the isopotential point) must be known. Using standard pH determination protocol, the sonde software assigns the isopotential point as the mv reading at pH 7 and then calculates the intercept using this assumption. Once the slope and intercept to the plot of pH vs. mv are assigned at the new temperature, the calculation of pH under the new temperature conditions is straightforward, and is automatically carried out by the sonde software.

MEASUREMENT AND CALIBRATION PRECAUTIONS

1- The 6561FG and 6565FG sensors are characterized by a flat glass pH sensor which is more rugged than the glass in traditional bulb-type pH sensors. Users should note, however, that the flat glass sensors are characterized by significantly higher impedance which makes them somewhat more susceptible to static interference when users are handling or are in close proximity to the sonde during calibration or other laboratory activities. The static interference can sometimes cause the pH readings observed during Discrete Sample studies or sensor calibration to be very jumpy. If this jumpiness is observed during calibration or use of a flat glass pH probe, users should simply avoid touching the sonde and should maintain a distance away from the sonde of at least 2 feet until the calibration has been confirmed. The static interference is particularly noticeable during winter when the air is drier.

2- When filling the calibration cup prior to performing the calibration procedure, make certain that the level of calibrant buffers is high enough in the calibration/storage cup to cover at least ½ inch of the pH probe and the temperature sensor of the 6560 probe.

3 - Rinse the sensors with deionized water between changes of calibration buffer solutions.

4 - During pH calibration, allow the sensors time to stabilize with regard to temperature (approximately 60 seconds) before proceeding with the calibration protocol. The pH readings after calibration are only as good as the calibration itself.

5- The true pH values of commercially-available buffers are slightly temperature dependent with the actual pH values at various temperatures usually shown on the bottle. For example, the actual pH of YSI "pH 7 buffer" at 20 C is 7.02 rather than the value of 7.00 at 25 C. Users who wish to obtain the maximum accuracy from their pH sensors should first determine the temperature of their buffers and then enter the proper pH reading for that temperature (from the bottle label) when carrying out calibration of pH.

6 - Clean and store the probe according to the instructions found in **Section 2.10, Care, Maintenance and Storage** of this manual.

5.6 DEPTH AND LEVEL

The sondes can be equipped with either depth or level sensors. In fact, both sensors measure depth, but by YSI convention, level refers to vented measurements and depth refers to non-vented measurements. Both measurements use a differential strain gauge transducer to measure pressure with one side of the transducer exposed to the water.

For depth measurements, the other side of the transducer is exposed to a vacuum. The transducer measures the pressure of the water column plus the atmospheric pressure above the water. Depth must be calculated from the pressure exerted by the water column alone; therefore, when depth is calibrated in air, the software records the atmospheric pressure and subtracts it from all subsequent measurements. This method of compensating for atmospheric pressure introduces a small error. Because the software uses the atmospheric pressure at the time of calibration, changes in atmospheric pressure between calibrations appear as changes in depth. The error is equal to 0.045 feet for every 1mm Hg change in atmospheric pressure. In sampling applications, frequent calibrations eliminate the error. Considering typical changes in barometer during long-term monitoring, errors of ± 0.6 feet (0.2m) would be common. In applications where this error is significant, we recommend using a level sensor in place of the depth sensor.

As with depth measurements, level uses a differential transducer with one side exposed to the water. However, the other side of the transducer is vented to the atmosphere. In this case, the transducer measures only the pressure exerted by the water column. Atmospheric pressure is ignored and changes in atmospheric pressure do not affect the reading at all.

The voltage output of the transducer is directly proportional to the pressure. The sonde software converts this voltage to a depth reading in feet or meters via calibration parameters that are factory installed. Readings are automatically compensated for the temperature and for the density of the environmental medium that is estimated from the measured salinity.

For more additional information on measuring level, see **Appendix G, Using Vented Level.**

CALIBRATION AND EFFECT OF TEMPERATURE

The depth sensor must be zeroed prior to deployment to account for atmospheric pressure. Level sensors may also require a small adjustment prior to their first use. This procedure is carried out by following the calibration menu instructions with the sonde in air only (do not submerge). The sensors can also be set to any known depth via the calibration routine after they are immersed. The temperature dependence of the sensor is automatically taken into account by the sonde software based on input from factory calibration.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) Be certain that the sonde is not immersed in water during the calibration procedure unless you know the exact distance between the sensor and the water surface. Calibration (zeroing) in air is usually the recommended method.

(2) Remember that the depth sensors for the sonde are not vented. In practical terms, this means that changes in barometric pressure after the sensor is calibrated will appear as changes in depth. This effect is significant, particularly for the 0-30 ft option of the depth probe. For example, a change of 1 mm of Hg in barometric pressure will change the apparent depth by approximately 0.045 feet (0.012 m). As noted above, this error is eliminated for level sensors because they are vented to the atmosphere.

5.7 TEMPERATURE

The sondes utilize a thermistor of sintered metallic oxide that changes predictably in resistance with temperature variation. The algorithm for conversion of resistance to temperature is built into the sonde software, and accurate temperature readings in degrees Celsius, Kelvin, or Fahrenheit are provided automatically. No calibration or maintenance of the temperature sensor is required.

5.8 DISSOLVED OXYGEN – 6562 RAPID PULSE POLAROGRAPHIC

The sondes employ the patented YSI Rapid Pulse system for the measurement of dissolved oxygen (DO). Use of this technology provides major advantages for the *monitoring* of DO without significantly compromising the accuracy of *sampling* applications. Standard electrochemical detectors of DO are highly flow-dependent and therefore require external stirring of the medium being evaluated. This stirring must be supplied either by an auxiliary stirrer (which can consume much of the battery reserve in a portable system) or by manually agitating the sonde when carrying out spot sampling applications (which can be inconvenient). These disadvantages are overcome by the Rapid Pulse dissolved oxygen technology that is associated with the sonde because it needs no stirring to yield accurate readings. In addition, because of the nature of the technology, some effects of fouling of the sensor are minimized.

The Rapid Pulse system utilizes a Clark-type sensor that is similar to other membrane-covered steady-state dissolved oxygen probes. The system still measures the current associated with the reduction of oxygen which diffuses through a Teflon membrane, and this current is still proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. The membrane isolates the electrodes necessary for this reduction from the external media, encloses the thin layer of electrolyte required for current flow, and prevents other non-gaseous, electrochemically active species from interfering with the measurement. However, as the user will note from examination of the 6562 probe, the sensor consists of three electrodes (a cathode, anode, and reference electrode) while steady state Clark probes usually have only two electrodes (a cathode and a combined anode-reference electrode). In addition, the geometry of the sensor is novel, consisting of a thin linear gold cathode placed between two silver rectangles which serve as anode and reference electrodes. These sensor changes were required to implement the Rapid Pulse method for DO measurement as described in the following section.

METHOD OF OPERATION

Standard Clark dissolved oxygen sensors, which are marketed by YSI and other manufacturers, are continuously polarized at a voltage sufficiently negative to cause oxygen to be reduced to hydroxide ion at the cathode and silver metal to be oxidized to silver chloride at the anode. The oxygen diffuses through the

Teflon membrane. The current associated with this process is proportional to the oxygen present in the solution outside the membrane. However, as this electrochemical reaction proceeds, oxygen is consumed (or depleted) in the medium, resulting in a decrease in measured current (and apparent oxygen content) if the external solution is not stirred rapidly. To minimize this oxygen depletion, the probe electrodes in the YSI Rapid Pulse system are rapidly and reproducibly polarized (on) and depolarized (off) during a measurement sequence. The Rapid Pulse system thus measures the charge or coulombs (current summed over a specific time period) associated with the reduction of oxygen during a carefully controlled time interval. The coulombs due to charging of the cathode (capacitance), but not to reduction of oxygen, are subtracted during integration after the cathode has been turned off. The net charge, like the steady state current in a standard system, is proportional to the oxygen partial pressure in the medium. Because oxygen is only being reduced 1/100th of the total measurement time, even if the probe is pulsed in this manner continuously, oxygen consumption outside the membrane is kept to a minimum, and the stirring dependence of the system is greatly reduced.

One key to the practicality of Rapid Pulse oxygen system is the fact that the "on time" is very short. This allows the "off time" to also be relatively short and still maintain the off to on ratio of 100 which is necessary to obtain relatively flow independent measurements. The second important aspect of the Rapid Pulse technology is the integration (summing of the current) over the total pulse (on and off). Because the charging current of the electrodes is subtracted in this process, the net signal is due only to the reduction of oxygen. From a practical point of view, this means that when there is zero oxygen partial pressure outside the membrane, the Rapid Pulse signal will also be zero; this in turn allows the system to be calibrated with a single medium (air or water) of known oxygen pressure.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde Rapid Pulse system is calibrated using the same basic methods employed for steady state oxygen sensors. However, the software that controls the calibration protocol is somewhat different depending on whether the unit will be used in sampling or deployment studies. For sampling studies using either a 650 MDS display unit or a laptop computer, the Rapid Pulse system is allowed to run continuously when the Calibration mode is activated if "Autosleep" is turned off. Under these software conditions, the user views the DO readings in real time and confirms the calibration manually after the readings have stabilized.

For studies in which the sonde is deployed and readings are saved less frequently (5 – 60 minutes) to sonde memory, a computer or data collection platform, an appropriate warm up time is selected for the system in the **Advanced|Sensor** menu. Usually 40 seconds is adequate for this parameter, but, in some cases, larger values may result in more accurate results. Most importantly for deployment studies, "Autosleep" should be activated. With these software entries in place, the user will input the calibration value (concentration or barometric pressure), and the unit will automatically calibrate after the selected warm up time.

The description below is designed around deployment applications with "Autosleep" activated.

The two general calibration methods possible with the sonde are "DO mg/L" and "DO %". The former method is designed for calibration in solution while the latter utilizes water-saturated air as the medium. Since the percent saturation (DO %) and concentration (DO mg/L) values are related, calibration by either method results in correct outputs in both units.

If the mg/L method is selected from the sonde Calibrate menu, the oxygen concentration of an aqueous solution may be determined by several methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated, or
- Measurement with another instrument.

If this calibration method is employed, place the sonde into this known-value solution and wait 5-10 minutes for equilibration to occur. Then input the value (in mg/L) into the sonde software and begin the calibration

protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.

If the Percent Saturation method is selected, the sonde is simply placed in a calibration cup that contains a small quantity of water or a damp sponge. ***The probe sensor should not be in the water for this calibration procedure.*** The sonde should be left under these conditions for 10-15 minutes to allow temperature and humidity equilibration to occur. Then input the true barometric pressure into the sonde software and begin the calibration protocol according to the instructions. The calibration will occur automatically at the end of the specified warm-up time.
NOTE: Remember that control of the calibration will be manual rather than automatic if the unit is set up properly for spot sampling applications ("Autosleep" deactivated).

The DO readings of steady state oxygen systems are greatly affected by temperature (approximately 3% per degree Celsius) due to the effect of temperature on the diffusion of oxygen through the membrane. The Rapid Pulse system exhibits a greatly reduced effect of temperature (approximately 1% per degree Celsius), but this factor still must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. The sonde software automatically carries out this compensation.

In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air saturated water (DOsat % = 100) contains 9.09 mg/L at 20 ^{o}C, but only 7.65 mg/L at 30 ^{o}C. The sonde software compensates for both of these temperature-related factors after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to solubility in mg/L is carried out automatically by the sonde software using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See **Appendix D, Solubility and Pressure/Altitude Tables** for dissolved oxygen solubility tables as a function of salinity and temperature.

FLOW DEPENDENCE

As noted above, oxygen readings acquired using the Rapid Pulse technology are much less affected by sample flow than steady state probes. However, there is a finite stirring dependence exhibited by the Rapid Pulse system if measurements are taken when the probe is being pulsed continuously. Our tests indicate that, under these sampling conditions, observed dissolved oxygen readings can be 2-3 percent lower than the true readings in very still water. Minimal movement of the water (which occurs during most environmental measurements) removes this effect.

This small flow dependence of the sensor is greatly reduced in longer term monitoring deployments where the sampling interval is longer, e.g. 15 minutes. Under these conditions, the sensor is pulsed for only approximately 40 seconds every 15 minutes, and normal diffusion of oxygen in the medium re-establishes the oxygen which has been depleted in the previous warm-up/read sequence.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

(2) For calibrations in water-saturated air, ensure that the calibration cup being used is vented or pressure released.

(3) If air-saturated water is used as the calibrating medium, make certain that the water is truly saturated by sparging it for at least 1 hour with an aquarium air-pump and air-stone.

(4) For short term storage (2 weeks or less), keep the probe moist when not in use, either by immersing in water or by placing a damp sponge in the calibration vessel. For longer-term storage, remove the probe from the sonde and store it in water with a membrane and electrolyte in place. If the membrane appears to be damaged or has dried out, be sure to replace it prior to calibration and deployment.

(65 Before you install a new membrane, make sure that the O-ring groove and the probe tip are clean and smooth. If the KCl electrolyte solution leaks from the probe surface during monitoring studies, the accuracy of the readings will be compromised.

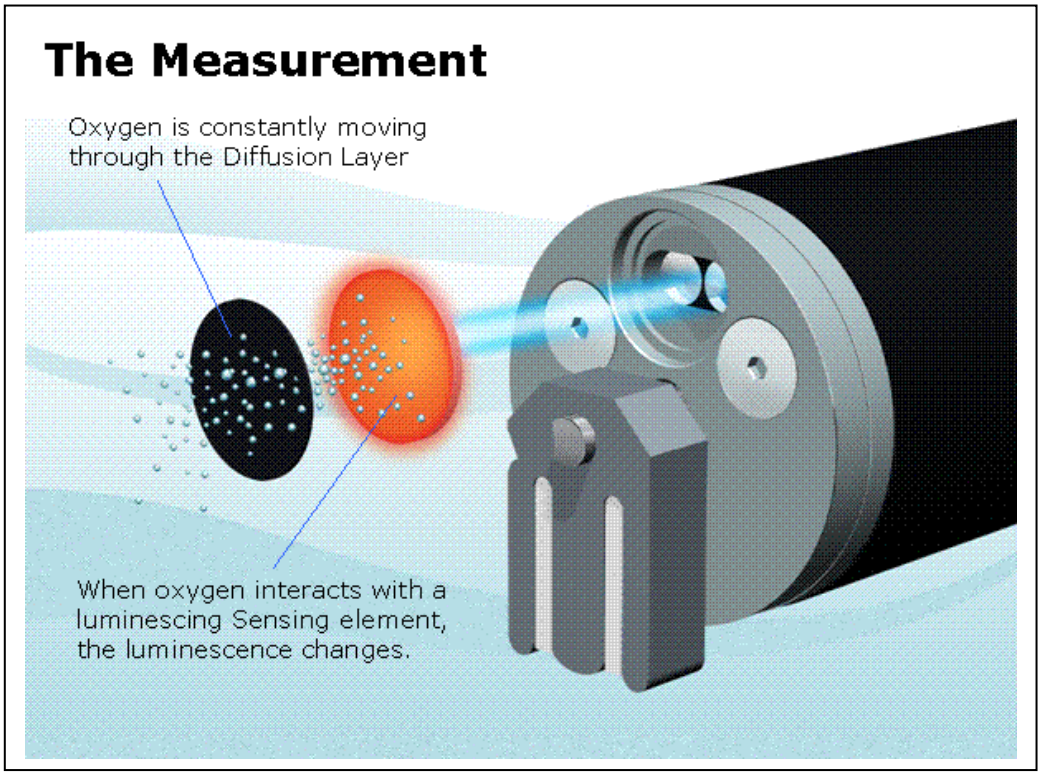
5.9 DISSOLVED OXYGEN – 6150 ROX OPTICAL

In general, optical dissolved oxygen sensors from a variety of manufacturers are based on the well-documented principle that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with carefully-chosen chemical dyes. The 6150 sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk about 0.5 inches in diameter. This dye-containing disk will be evident on inspection of the sensor face. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation. For most lifetime-based optical DO sensors (including the YSI 6150), this Stern-Volmer relationship (((Tzero/T) – 1)) versus O_2 pressure) is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression rather than the simple linear regression used for most polarographic oxygen sensors. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time. The 6150 probe is warranted for 2 years and sensor modules are warranted for 1 year by YSI.

Each YSI sensor module (the assembly which is attached to the face of the probe by three screws) is factory-calibrated over a range of 0-100 percent oxygen to quantify the relationship of its luminescence lifetime as a function of oxygen pressure. The Stern-Vollmer parameters from this data are then fit to a third order regression equation ($ax^3 + bx^2 + cx$) and values of a, b, and c determined. These coefficients, along with the luminescence lifetime at zero oxygen pressure (Tzero), are provided to the user in coded form with each sensor membrane module or probe/sensor module combination. If you install a replacement sensor membrane assembly (YSI 6155) on your existing probe, you will be required to enter these coded constants into the sonde as described in the instructions which come with the 6155 prior to the use of the sensor. If you have purchased a probe/membrane combination, i.e. a new 6150 Optical DO sensor, the constants are already stored in your probe and will automatically be transferred to your sonde when the sensor is installed.

A schematic representation of the 6150 ROX Optical DO sensor is shown in the picture below:



EFFECT OF TEMPERATURE AND SALINITY

In terms of the determination of dissolved oxygen in environmental water, the 6150 is similar to standard membrane-covered dissolved oxygen probes in that its measured parameter is proportional to the partial pressure (not the concentration) of oxygen in the solution being evaluated. This partial pressure value is reported as "Percent Air Saturation". The signal from the 6150 system is affected by temperature (approximately 1.50% per degree Celsius), and this factor must be accounted for if DO readings acquired at temperatures different from that at calibration are to be accurate. The sonde automatically carries out this compensation. In addition, the relationship between the measured partial pressure of oxygen (percent saturation) and the solubility of oxygen in mg/L is very temperature dependent. For example, air-saturated fresh water contains 9.09 mg/L at 20 °C, but only 7.65 mg/L at 30 °C. The sonde compensates for both of these temperature-related factors after instrument calibration. The temperature compensation for the percent saturation reading is empirically derived, while the conversion from percent saturation and temperature to solubility in mg/L is automatically carried out using formulae available in *Standard Methods for the Examination of Water and Wastewater (ed. 1989).* See **Appendix D, Solubility and Pressure/Altitude Tables** of the manual supplied with your 6-series sonde for dissolved oxygen solubility tables as a function of salinity and temperature.

While the measured partial pressure of air-saturated water is not a function of the salinity (or solids content) of the water, the concentration of oxygen at a given partial pressure changes significantly with salinity. Thus, air-saturated freshwater (salinity = 0) at 20 °C contains 9.09 mg/L of oxygen while air-saturated sea water (salinity = 35) contains only 7.35 mg/L. This effect is automatically accounted for when the firmware in your 6-series sonde calculates DO mg/L, as long as the conductivity sensor is active and properly calibrated.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) If water-saturated air is used as the calibrating medium, make certain that *both the DO reading and the temperature* have stabilized (10-15 minutes) before starting the calibration sequence. A wet thermistor can indicate artificially low temperature readings due to evaporation and this situation will result in poor temperature compensation and inaccurate readings.

(2) If air-saturated water is used as the calibrating medium, make certain that the water is truly air-saturated by sparging with an aquarium air-stone for at least 1 hour prior to implementing the calibration procedure.

(3) If calibrating in water-saturated air, insure that the calibration cup being used is vented or pressure released.

(4) When not in use, you MUST keep the probe moist, either by immersing in water or by covering the membrane on the probe tip with the plastic cap/moist sponge which was in place on the sensor when it was received.

(5) If you inadvertently leave your sensor exposed to ambient air for a period of more than approximately 2 hours, you can rehydrate the membrane by the following method: (1) Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and leave it at the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air prior to calibration and deployment. **CAUTION: MAKE CERTAIN THAT THE WATER IN THE VESSEL DOES NOT COMPLETELY EVAPORATE DURING THE REHYDRATION STEP.**

(6) To assure that the best possible accuracy for the ROX Optical DO sensor, YSI recommends that the membrane assembly be replaced after 1 year. The 6155 Optical DO Membrane Replacement Kit can be ordered from YSI Technical Support.

For more information on the practical aspects of using the 6150 ROX dissolved oxygen sensor, see **Appendix M** of this manual.

5.10 NITRATE

The sonde nitrate probe consists of a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with nitrate ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of nitrate in the sample and the internal filling solution. This potential is read relative to the Ag/AgCl reference electrode of the sonde pH probe. As for all ISEs, the linear relationship between the logarithm of the nitrate activity (or concentration in dilute solution) and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in nitrate activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 53-58 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known nitrate concentration (typically 1 mg/L and 100 mg/L NO_3-N). The slope of the plot of log (nitrate) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (nitrate) vs. voltage intersects the calibration plot is called the isopotential point, that is, the nitrate concentration at which changes in temperature cause no

change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and you should recalibrate the probe periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. For example, chloride ion binds in this way to the nitrate membrane and produces positive nitrate readings even when no nitrate is present in the medium. Fortunately, most fresh water does not usually contain significant quantities of ions that produce a large interference on the nitrate reading, such as azide, perchlorate, and nitrite. It usually does contain some chloride and carbonate ions, but the interference from these ions is relatively small. For example, if the all of the ionic content of water with a conductivity of 1.2 mS/cm (Sal = 0.6) were due to the presence of sodium chloride, the nitrate reading would be erroneously high by about 1.6 mg/L. If the conductivity in this sample were all due to sodium bicarbonate, the sensor output would indicate the presence of only 0.2 mg/L of non-existent nitrate from the interference.

Even though the interference from chloride is relatively small and thus tolerable at low salinity, the large quantity of this species in salt or brackish water creates interference so great as to make the sensor unsuitable for these media.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all-interfering species produce an artificially high nitrate reading. Thus, if the sonde indicates the presence of only small quantities of nitrate, it is unlikely that the reading is erroneously low because of interference. Unusually high nitrate readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ion selective electrodes have the greatest tendency to exhibit calibration drift over time of all the sensors available on the sonde. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if a nitrate sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another nitrate sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The nitrate sensor should be calibrated using solutions of known nitrate-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can

use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Nitrate standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the nitrate sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during nitrate calibration after exposure to buffers.

CAUTION**:** *The nitrate membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor***.**

5.11 AMMONIUM AND AMMONIA

The sonde ammonium probe employs a silver/silver chloride (Ag/AgCl) wire electrode in a custom filling solution. Nonactin membrane separates the internal solution from the sample medium and this membrane selectively interacts with ammonium ions. When the probe is immersed in water, a potential is established across the membrane that depends on the relative amounts of ammonium in the sample and the internal filling solution. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the ammonium activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in ammonium activity at 25°C. In practice, however, empirical calibration of the electrode is necessary to establish an accurate slope of the response. Typical empirical slopes are 53-58 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known ammonium concentration (typically 1 mg/L and 100 mg/L NH_4^+-N).

The slope of the plot of log (ammonium) vs. voltage is also a function of temperature. The slope changes by a factor that is the ratio of the absolute temperature of calibration to absolute temperature of measurement. The point where this new plot of log (ammonium) vs. voltage intersects the calibration plot is called the isopotential point, that is, the ammonium concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, use a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset, and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to interference from ions, which are similar in nature to the analyte. For example, sodium and potassium ions bind to the ammonium membrane and produce positive readings even when no ammonium is present. Fortunately, fresh water does not usually contain enough interfering ions to produce large errors. For example, a common conductivity for freshwater is about 1.2 mS/cm (Sal

= 0.6). Even if the ionic content were due to sodium chloride, the ammonium reading would be erroneously high, about 0.4 mg/L.

However, brackish or seawater has enough sodium and potassium to cause interference so great as to make the sensor unsuitable for these media.

The sensor used in the sonde detects only ammonium ions (NH_4^+), the predominant form of total ammonium nitrogen in most environmental samples. However, using the concurrently determined values of pH, temperature, and conductivity, the sonde software can also provide the user with the concentration of free ammonia (NH_3) in the sample under investigation.

Ammonium ions and free ammonia are in equilibrium in any solution according to the following equation:

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

The value of the equilibrium constant associated with this reaction, $K = [NH_3][H^+]/[NH_4^+]$, and its variation with temperature and salinity, is well known. This information allows the free ammonia concentration $[NH_3]$ to be automatically calculated by the sonde software and displayed if this parameter is activated.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. To check for this drift, place the sonde in one of your standards at the end of each deployment.

(4) Ammonium standards are good growth media for a variety of organisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each deployment, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

(5) Remember that the ammonium sensor will take longer to stabilize after exposure to buffers in a sonde pH calibration. To accelerate this process, soak the sensor in 100 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during ammonium calibration after exposure to buffers.

CAUTION**:** *The ammonium membrane module is for use only at depths less than 50 feet (15.2 meters). Use of the probe at greater depths is likely to permanently damage the sensor.*

5.12 CHLORIDE

The sonde chloride probe employs a solid state membrane attached to a conductive wire. When the probe is immersed in water, a potential is established across the membrane that depends on the amount of chloride in the medium. This potential is read relative to the reference electrode of the sonde pH probe. As for all ISEs, there is a linear relationship between the logarithm of the chloride activity (or concentration in dilute solution) and the observed voltage. The Nernst equation describes this relationship.

Under ideal conditions, the Nernst equation predicts a response of 59 mV for every 10-fold rise in chloride activity at 25°C. However, in practice, empirical calibration of the electrode is necessary to establish the slope of the response. Typical slopes are 45-55 mV per decade for YSI sensors. This slope value is determined by calibration with two solutions of known chloride concentration (typically 10 mg/L and 1000 mg/L Cl^-).

The slope of the plot of log (chloride) vs. voltage is also a function of temperature, changing from its value at calibration by a factor of the ratio of the absolute temperatures at calibration to that at measurement. The point where this new plot of log (chloride) vs. voltage intersects the calibration plot is called the isopotential point, that is, the chloride concentration at which changes in temperature cause no change in voltage. Our experience with ISEs indicates that for best accuracy, the isopotential point should be determined empirically. To do so, the user employs a third calibration point where the voltage of the lower concentration standard is determined at a temperature at least 10°C different from the first two calibration points. The slope, offset and isopotential point drift slowly, and the probe should be recalibrated periodically.

All ion selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high chloride reading. Thus, if the sonde indicates the presence of only small quantities of chloride, it is unlikely that the reading is erroneously low because of interference. Unusually high chloride readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the

instrument can be frequently calibrated. However, if a chloride sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another chloride sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 15 % of the reading or 5 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

CALIBRATION AND EFFECT OF TEMPERATURE

The chloride sensor should be calibrated using solutions of known chloride content according to the procedures detailed in **Sections 2.6.1 and 2.9.2**. If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10 degrees Celsius different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different ambient laboratory temperatures.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) The temperature response of ion selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the probe. This will provide a default setting for the effect of temperature on your particular sensor. After this initial calibration, you can use the less time-consuming 2 point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

(2) Ion selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

(3) Ion selective electrodes generally drift more than pH sensors. Be sure to check for this drift by placing the sonde in a standard at the end of each deployment.

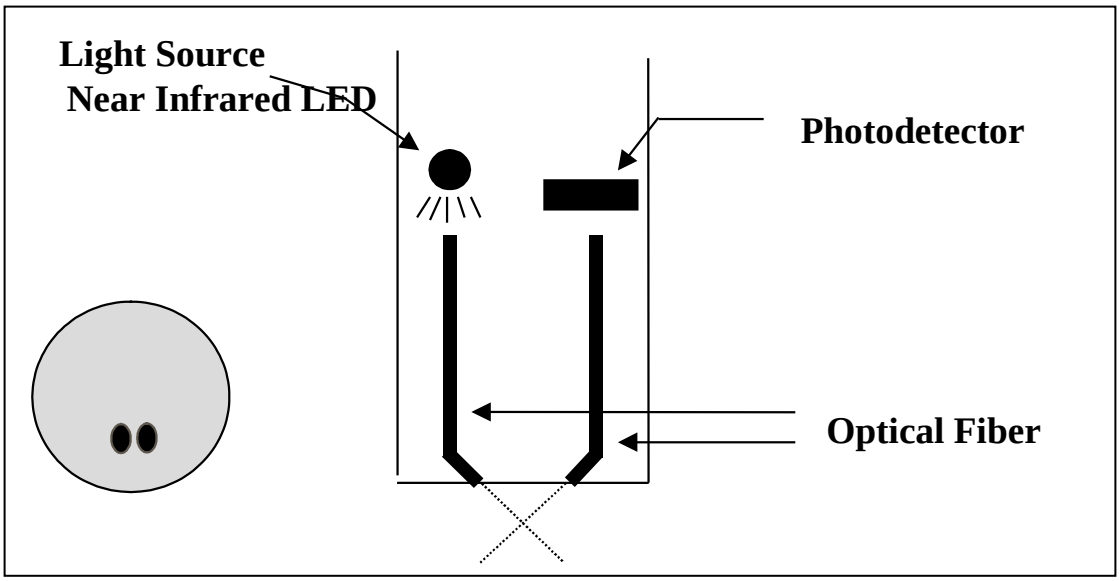
(4) Remember that the chloride sensor will take longer to stabilize after exposure to pH buffers. To accelerate this process, soak the sensor in 1000 mg/L standard for a few minutes after performing a pH calibration. In addition, be particularly careful that readings are stable during chloride calibration after exposure to buffers.

5.13 TURBIDITY

Turbidity is the measurement of the content of suspended solids (cloudiness) in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the particles which are present. For turbidity systems capable of field deployment, the usual light source is a light emitting diode (LED) which produces radiation in the near infrared region of the spectrum. The detector is usually a photodiode of high sensitivity. The angle between the emitted and detected light varies (usually between 90 and 180 degrees) depending on the probe used. The International Standards Organization (ISO) recommends the use of a light source with a wavelength between 830 and 890 nm and an angle of 90 degrees between the emitted and detected radiation (ISO 7027).

The turbidity system available as an option for use with YSI 6-series sondes consists of a probe which conforms to the above ISO recommendations. The output of the sonde turbidity sensor is processed via the

sonde software to provide readings in nephelometric turbidity units (NTUs). A schematic of a YSI turbidity sensor is shown in the following picture.



Two turbidity probes have been available for use with YSI 6-series sondes – the 6026 and the 6136. The 6026 probe is no longer available from YSI, but since a large number of this probe type are still in use, a description of the sensor will be included in this section. The probes are detailed briefly below; both are equipped with a mechanical wiper to periodically clean the sensor either by manual or automatic activation. These wiper systems make the probe ideal for long term monitoring, but they also work well for spot sampling applications.

- The Model 6026 probe was offered by YSI from 1995 to approximately 2002 and is characterized by relatively small optics, a factor that results in minimal penetration of the light beam into the sample and thus allows the use of shorter probe guards on the sonde in which it is installed. If a 6026 sensor is selected in the Sensor menu of the sonde, the turbidity will automatically be reported in the units "turbid NTU".

- The Model 6136 has been the only turbidity probe sold by YSI since 2002 and it is characterized by relatively large optics compared to the 6026. Since these larger optics result in deeper penetration of the light beam into the sample, the use of a longer probe guard is required, a slight disadvantage. However, the larger optical cell volume of the sensor has two significant advantages: (1) There is less background noise associated with the turbidity readings and (2) the absolute values of the readings are significantly closer to those from typical laboratory turbidimeters (such as the Hach 2100AN) which use a large cell volume. If a 6136 sensor is selected in the Sensor menu of the sonde, the turbidity will automatically be reported in the units "turbid+ NTU".

In the primary standard formazin, the two turbidity sensors (6026 and 6136) will show effectively identical behavior. In addition, AEPA-AMCO polymer beads (supplied by YSI as Model 6073) can also be used with one important qualification. You will need to remember that the 6026 and 6136 sensors, which read the same in formazin suspensions, will have different responses in the suspensions of the AEPA-AMCO beads. This effect is due to the larger optical cell volume of the 6136. Thus, as noted on the label of the

turbidity standards supplied by YSI, the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.**

In environmental water that contains suspended particles of varying size and density, the readings for the two probes will also differ after calibration with either formazin or polymer beads, with the 6026 almost always showing higher readings and the extent of the difference generally being proportional to the overall turbidity. For example, if both probes are calibrated at 0 and 100 NTU and then placed in a turbid river, the 6026 might read 400 NTU while the 6136 would read 300 NTU. The absolute difference in the sensor readings would shrink as the turbidity dropped. Thus, if the 6026 read 30 NTU, the 6136 would likely read approximately 21 NTU.

Note that the sonde software labels the output of the two sensors with slightly different units of turbidity ("turbid NTU" for the 6026 and "turbid+ NTU" for the 6136) so that the user will readily be able to determine which sensor was used in a particular study during later data analysis.

No matter whether the 6026 or 6136 is installed in your sonde, it is important to remember that field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can generally be removed in short term sampling applications by simply agitating the sonde manually. However, for studies longer than a few hours where the user is not present at the site, the quality of the turbidity data obtained with a turbidity sensor that has no capability of mechanical cleaning is likely to be poor. However, as noted above, both the 6026 and the 6136 probes are equipped with a mechanical wiper that makes them ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically during long term unattended sampling studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally one movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde software offers the option of 1-point, 2-point, or 3-point calibrations procedures. For most applications, a 2-point calibration at 0 and approximately 100 NTU is sufficient for either the 6026 or the 6136 sensor. However, a user might wish to carry out a 3-point calibration at values of approximately 0, 100 and 1000 NTU to provide maximum accuracy over the entire normally encountered environmental turbidity range (0-1000 NTU). If the range of turbidity in the environmental sample is well known, standards of other turbidity values can be utilized (in either 3 point or 2 point routines). However, in all calibration procedures, one of the standards must be 0 NTU and this should be the first calibration point.

NOTE: Before calibrating your 6026 or 6136 turbidity sensor, pay particular attention to the following cautions:

- For all calibration procedures, you MUST use standards that are based on either formazin or AMCO-AEPA styrene divinylbenzene beads as described in *Standard Methods for the Examination of Water and Wastewater* and have been prepared either by Hach (formazin based) or AMCO-AEPA based standards prepared by YSI or an approved YSI vendor listed on the YSI website (www.ysi.com). THE USE OF STANDARDS FROM OTHER VENDORS AND/OR THOSE PREPARDED FROM MATERIALS OTHER THAN FORMAZIN OR AMCO-AEPA POLYMER BEADS WILL RESULT IN BOTH CALIBRATION ERRORS AND INACCURATE FIELD READINGS.

- <u>For AMCO-AEPA standards, the value entered by the user during the calibration protocol is DIFFERENT depending on which sensor (6026 or 6136) is being calibrated.</u> This reflects the empirically determined fact that the 6026 and 6136 sensors which have been calibrated to the same value in the primary standard formazin will have <u>different responses in the suspensions of the AEPA-AMCO</u> beads. This effect is likely due to the larger optical cell volume of the 6136. Thus, for

example, the label of the YSI 6073 turbidity standard bottle indicates that the value of the standard is **100 NTU when used for calibration of the 6026 sensor, but 126 NTU when used to calibrate the 6136.** Note that the phenomenon of a sensor-specific formazin/AEPA-AMCO ratio is well known for sensors other than the 6026 and 6136.

YSI and its approved vendors offer easy-to use AMCO-AEPA turbidity standards which can also be quantitatively diluted with turbidity-free water to provide calibrant suspensions of lower values. Hach also offers relatively inexpensive formazin suspensions at various NTU values up to 1000 NTU under the Stablcal™ designation which will provide accurate calibration of either the 6026 or 6136 sensors as long as the user is willing to exercise the proper safety precautions as outlined in the MSDS associated with formazin. The primary advantage of the Hach formazin standards is their cost; their primary disadvantage is that the suspended matter settles out fairly rapidly. Although the AMCO-AEPA standards are somewhat more expensive, they do not settle out, making them significantly easier to use.

While the effect of temperature on the turbidity sensor is small, this factor is automatically taken into account by the sonde software providing temperature compensated readings. Temperature coefficients of 0.3%/degree C and 0.6%/degree C are automatically activated for the 6026 and 6136, respectively, when these sensors are activated in the **Sensor** menu.

MEASUREMENT AND CALIBRATION PRECAUTIONS

(1) For best results, use only freshly prepared or purchased turbidity standards. Degradation of standards can occur on standing, particularly formazin prepared from dilution of concentrated suspensions such as Hach 4000 NTU standard.

(2) If unusually high or jumpy readings are observed during the calibration protocol, it is likely that there are bubbles on the optics. Manually activating the wiper of the 6026 or 6136 from a computer or 650 MDS keypad removes these bubbles.

(3) When calibrating the 6136 sensor, be aware of the fact that precautions must be taken to avoid interference of the bottom of the calibration vessel. Instructions for two methods of calibrating the 6136 sensor are provided in Section 2.6.1 of this manual. Unless these precautions are taken, field turbidity readings can exhibit an offset of approximately 1.5 NTU. For example, a field reading of 2.5 NTU would really be 4.0 NTU. The offset is not magnified at higher turbidity (for example, a reading of 100 NTU would really be 101.5 NTU) and thus, the effect is much more important in water of low turbidity.

(4) The output of turbidity sensors is susceptible not only to the overall cloudiness of the environmental medium, but also to the particle size of the suspended solids which pass across the optics on the probe face. Thus, although the turbidity of an environmental sample may appear to the eye to be relatively stable, the displayed turbidity can vary significantly depending on the nature of the particles in the optical path at the instant of measurement. For example, if individual readings are taken every 4 seconds in a discrete sample study of environmental water, variations of 0.5-1.0 NTU are common between readings. In long term, unattended studies this effect can be even more exaggerated with spikes of up to 10 NTU sometimes observed. This apparent jumpiness is not observed for freshly prepared turbidity standards, since the particle size in these suspensions is homogeneous.

The sonde turbidity system allows the user to either observe these real turbidity events (while obtaining somewhat jumpy readings) or to apply a mathematical filter to the raw data so that the NTU output may be more reflective of the overall cloudiness of the environmental sample. From the **Advanced|Data Filter** menu of the sonde software, the user can activate the data filter that is specific to turbidity and "fine tune" its performance. For typical sampling and monitoring applications, YSI recommends that the Data Filter settings be selected as follows: Enabled -- On; Wait for Filter -- Off; Time Constant = 12; Threshold = 0.010.

For most unattended sampling applications, selection of the above filter settings should also be appropriate. However, an additional capability is also available which enhances the elimination of spurious single point spikes from the logged data and thus allows for a better presentation of the average turbidity during the deployment. This "**Turb Spike Filter**" is activated/deactivated in the **Advanced|Sensor** menu. Its capability is further described in **Section 2.9.8, Advanced**. YSI recommends the use of this feature for all unattended studies. The user should determine from experience whether its activation is also appropriate for spot sampling studies at particular sites.

See **Appendix E, Turbidity Measurements** for additional practical information on the measurement of turbidity with 6-series sondes.

5.14 CHLOROPHYLL

INTRODUCTION

Chlorophyll, in various forms, is bound within the living cells of algae, phytoplankton, and other plant matter found in environmental water. Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, the critical process in which the energy from sunlight is used to produce life-sustaining oxygen. In general, the amount of chlorophyll in a collected water sample is used as a measure of the concentration of suspended phytoplankton, the magnitude of which can significantly affect the overall quality of the water.

The use of the measurement of phytoplankton as an indicator of water quality is described in Section 10200 A. of *Standard Methods for the Examination of Water and Wastewater*. The classical method of determining the quantity of chlorophyll at a particular site is to collect a fairly large water sample and analyze it in the laboratory. The procedure involves filtration of the sample to concentrate the chlorophyll containing organisms, mechanical rupturing of the collected cells, and extraction of the chlorophyll from the disrupted cells into the organic solvent, acetone. The extract is then analyzed by either a spectrophotometric method using the known optical properties of chlorophyll or by high performance liquid chromatography (HPLC). This general method is detailed in Section 10200 H. *of Standard Method* and has been shown to be accurate in multiple tests and applications as long as a competent laboratory analyst carries out the protocol. The procedure is generally accepted for reporting in scientific literature. The method is time-consuming, however, and usually requires an experienced, efficient analyst to generate consistently accurate and reproducible results. It also does not lend itself readily to continuous monitoring of chlorophyll, and thus phytoplankton, since the collection of samples at reasonable time intervals, e.g., every hour, would be extremely tedious.

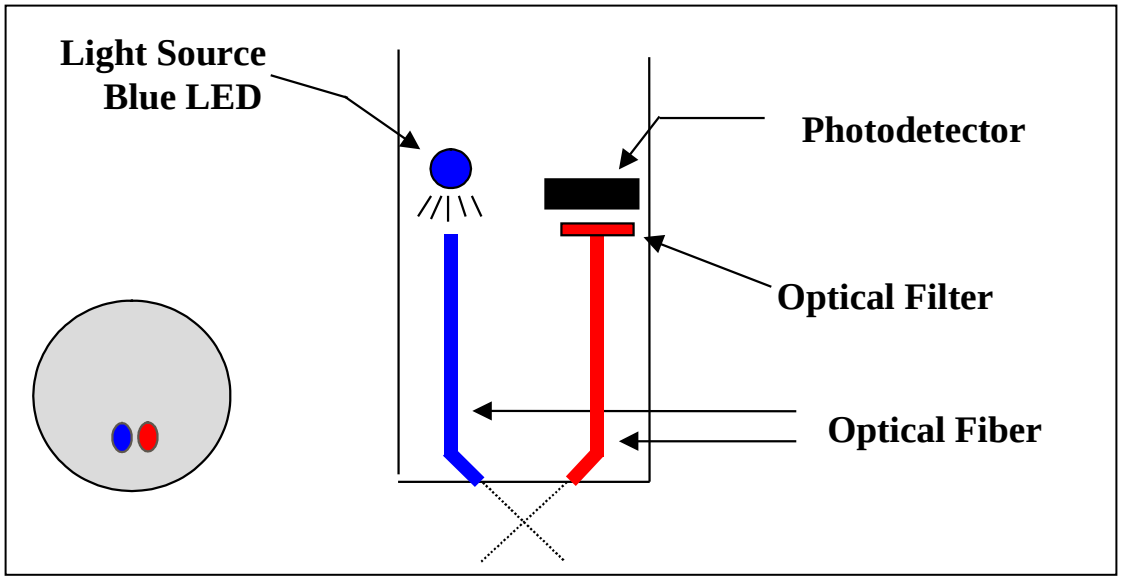
YSI has developed the YSI 6025 chlorophyll sensor for the determination of chlorophyll in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of chlorophyll which overcomes these disadvantages, albeit with the potential loss of accuracy. In this procedure, chlorophyll is determined *in vivo*, i.e., without disrupting the cells as in the extractive analysis. The YSI 6025 chlorophyll sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of chlorophyll data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will not be as accurate as those from the certified extractive analysis procedure.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making chlorophyll determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6025 with data from extractive analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the estimates of chlorophyll concentration from the easy-to-use YSI

chlorophyll system are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of chlorophyll determination.

MEASUREMENT OF CHLOROPHYLL *IN VIVO*

One key characteristic of chlorophyll is that it fluoresces, that is, when irradiated with light of a particular wavelength, it emits light of a higher wavelength (or lower energy). The ability of chlorophyll to fluoresce is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. Fluorometers of this type have been in use for some time. These instruments induce chlorophyll to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the higher wavelength light which is emitted as a result of the fluorescence process. Most chlorophyll systems use a light emitting diode (LED) as the source of the irradiating light that has a peak wavelength of approximately 470 nm. LEDs with this specification produce radiation in the visible region of the spectrum with the light appearing blue to the eye. On irradiation with this blue light, chlorophyll resident in whole cells emits light in the 650-700 nm region of the spectrum. To quantify the fluorescence the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the 470 nm exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain fluorescent phytoplankton, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



Most commercial fluorometers fit into two categories. In the first category are benchtop instruments that generally have superior optical flexibility and capability but are relatively expensive and are often difficult to use in the field. In the second category are sonde-type fluorometers that have a fixed optical configuration, but are less expensive, can be more easily used in the field, and are usually compatible with data collection platforms. The use of a pump is recommended for some sonde fluorometers and this can result in the need for large capacity batteries for field use.

The unique YSI chlorophyll system available as an option for use with YSI sondes consists of a probe which is similar in concept to the sonde-type fluorometers, but is much smaller, making it compatible with the probe ports of the YSI 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 600 OMSV2-1, 6600V2-2, 6600EDS V2-2, and 6600V2-4 sondes. The output of the sensor is automatically processed via the sonde software to provide readings in either relative fluorescence units (Chl RFU) or µg/L of chlorophyll. No pump is required for the YSI system allowing the sensor to operate off of either the sonde internal batteries or the batteries in the YSI 650 MDS display/logger. Like the YSI 6026 and 6136 turbidity probes, the YSI

6025 chlorophyll probe is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With these features, the YSI chlorophyll sensor provides the same level of performance as the sonde fluorometers, but is much easier to use and can be deployed in environmental water for several weeks without the need for service. In addition, the probe will be a component in sondes that can acquire up to ten other parameters simultaneously with chlorophyll, rather just providing the single parameter.

CALIBRATION METHODS -- GENERAL

As described in **Section** 2 of this manual, the sonde software offers the option of performing 1-point, 2-point, or 3-point calibration procedures in µg/L of chlorophyll. The 1-point calibration is designed only to zero the sensor in chlorophyll-free water and is sufficient for most field applications as described below. Performing a 1-point calibration also zeroes the relative fluorescence unit (RFU) parameter. The 2-point calibration will normally be used for checking the stability of the sensor during deployment by using a dye solution to set the relative sensitivity of the sensor as described below. The 3-point calibration routine is only for special applications and seldom improves the accuracy of the sensor.

For calibration of the YSI chlorophyll system, **only one type of standard will assure accurate field readings: a suspension of phytoplankton of known chlorophyll content**. The chlorophyll content of this suspension should be determined by the extractive analysis procedure described in *Standard Methods*. Most users will not have this analyzed plankton suspension available prior to field studies for use in the 2-point calibration protocol resident in the sonde software. Thus, the best "calibration" method usually comprises the following steps:

1. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 ug/L.
2. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
3. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
4. On return to the laboratory, perform extractive analyses for chlorophyll on the grab samples and record the results for later use.
5. After the study is complete, place your YSI chlorophyll data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or 'postcalibration") of your field results into accurate chlorophyll readings (relative to extractive analysis).
6. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6025 data.

A variation of this method is to perform a 2-point calibration prior to deployment using clear water and a dye standard, setting apparent chlorophyll equivalent of the dye standard to the value shown in the tables below. However, it must be emphasized that this technique does not increase the accuracy of the chlorophyll sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab sample and perform laboratory analysis to be assured of meaningful chlorophyll values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF DYE SOLUTIONS FOR CHECKING SENSOR DRIFT

RHODAMINE WT STANDARD SOLUTION

CAUTION: Be certain to read and follow all the safety instructions and MSDS documentation which is supplied with the dye before proceeding. Remember that only trained personnel should handle chemicals.

Use the following procedure to prepare a Rhodamine WT solution for use as a sensor stability check reagent.

1. Rhodamine WT dye is usually purchased in solution form and can vary somewhat in nominal concentration. YSI uses Rhodamine WT from the supplier noted below and recommends that the user purchase this exact item if possible. The solution is approximately 2 % in Rhodamine WT.

   Fluorescent FWT Red Dye (Item 106023)
   Kingscote Chemicals
   3334 South Tech Blvd.
   Miamisburg, OH 45342
   1-800-394-0678
   Fax: 937-886-9300

2. Accurately transfer 5.0 mL of the Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 100 mg/L of Rhodamine WT. Transfer this standard to a glass bottle and retain it for future use.

3. Accurately transfer 5.0 mL of the solution prepared in the above step to a 1000 mL volumetric flask and then fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution, which is 0.5 mg/L in water (a 200:1dilution of the concentrated solution).

4. Store the concentrated standard solution produced in (2) above in a glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 24 hours of its preparation.

When Rhodamine standards are required in the future, perform another dilution of the concentrated Rhodamine solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when “calibrating” the YSI chlorophyll sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The “Chl Tempco” factor in the Advanced|Sensor menu, MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate algal chlorophyll equivalent of 0.5 mg/L Rhodamine WT as a function of temperature.

T, C	ug/L Chl to Enter	T, C	Ug/L Chl to Enter
30	100	18	122
28	103	16	126
26	106	14	131
24	110	12	136
22	113	10	140
20	118	8	144

REMEMBER: The use of Rhodamine WT for "calibration with Rhodamine WT is only an approximation. To assure accurate readings from the 6025 sensor, the user must relate the field fluorescence readings to data from extractive analysis samples as described above. YSI does not provide an accuracy specification for chlorophyll due to these limitations.

EFFECT OF TEMPERATURE ON READINGS

While the effect of temperature on the chlorophyll sensor itself is very small, YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence. For example, the apparent chlorophyll content of our laboratory test samples of algae increased from 185 to 226 µg/L when the temperature was dropped from 21 °C to 1 °C even though no change in phytoplankton content took place. In the absence of compensation, this effect would obviously result in errors in field chlorophyll readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a chlorophyll temperature compensation routine ("Chl tempco") resident in the sonde software under the **Advanced|Sensor** menu.

From our studies, it appears that entry of a value of 1 to 2 % per degree C for "Chl tempco" is appropriate to partially account for changes in the fluorescence of environmental phytoplankton with temperature. This value can be estimated in the above example as follows:

Change in Temperature = 21–1 = 20 °C
Change in Fluorescence = 226-185 = 41 µg/L
% Change in Fluorescence = (41/185) x 100 = 22.1
Chl Tempco Factor = 22.1/20 = 1.11 % per degree °C

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of phytoplankton is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with phytoplankton standards of known chlorophyll content that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON CHLOROPHYLL MEASUREMENTS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde manually. For studies longer than a few hours where the user is not present at the site, the quality of the chlorophyll data obtained with a fluorescence sensor that has no capability of mechanical cleaning is likely to be compromised. The YSI 6025 probe is equipped with a mechanical

wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

EFFECT OF TURBIDITY ON CHLOROPHYLL READINGS

As described above, the filters in front of the photodiode in the YSI 6025 chlorophyll probe prevent most of the 470 nm light which is used to excite the chlorophyll molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on chlorophyll readings from suspended solids may result. Laboratory experiments indicate that a suspension of typical soil measured with a YSI turbidity sensor will have a turbidity interference characterized by a factor of about 0.03 µg/L per NTU. For example, the turbidity of the water must be above 100 NTU to produce an apparent chlorophyll reading equal to 3 µg/L. In very cloudy water, the user may wish to use the independently-determined turbidity value and the above compensation factor to correct measured chlorophyll values using, for example, a spreadsheet.

LIMITATIONS OF *IN VIVO CHLOROPHYLL* MEASUREMENTS

As noted above, the measurement of chlorophyll from *in vivo* fluorescence measurements will always be less reliable than determinations made on molecular chlorophyll that has been extracted from the cells using the procedures described in *Standard Methods*. This section describes some of the known problems with *in vivo* chlorophyll measurement.

INTERFERENCES FROM OTHER FLUORESCENT SPECIES: The analytical methods described in *Standard Methods* for chlorophyll involve disruption of the living organisms present in suspension, followed by extraction of molecular chlorophyll into a homogeneous solution in an organic solvent. Acidification of the extract helps to minimize the interferences caused by a number of other, non-chlorophyll species. In addition, readings can be taken at various wavelengths on a spectrophotometer to differentiate between the various forms of chlorophyll (a, b, c) and pheophytin a.

In contrast to this fairly controlled situation, all *in vivo* sensors operate under whole-cell, heterogeneous conditions where the sensor will measure, at least to some degree, everything which fluoresces in the region of the spectrum above 630 nm when irradiated with 470 nm light. Therefore, the sensor is really quantifying overall fluorescence under these optical conditions, rather than chlorophyll specifically. While it is probable that most of the fluorescence is due to suspended plant and algal matter and that much of the fluorescence from this biomass is due to chlorophyll, it is impossible to exclude interferences from other fluorescent species using the approach described above.

Note that *in vivo* fluorometers usually cannot differentiate between the different forms of chlorophyll.

LACK OF CALIBRATION REAGENTS: The usual reagents which are used for the calibration of fluorometric measurements for chlorophyll after extraction into organic solvents are purchased as "purified chlorophyll a" from chemical supply vendors such as Sigma. These standards are not soluble in aqueous media and, even if they were, their fluorescence is unlikely to be the same as when the chlorophyll is present in the whole living cell. Therefore, for even a semiquantitative calibration, the user needs a "substitute" standard such as Rhodamine WT (see above) to provide a method for estimating the sensitivity of the sensor. Field readings based on this type of calibration will provide only an estimate of chlorophyll in environmental water where the measurement is taken on whole cell suspensions *in vivo*. The calibration

standard that provides the best measure of accuracy for *in vivo* chlorophyll sensors is a portion of a phytoplankton suspension that has been analyzed for chlorophyll by the extractive procedure. We recommend the use of this procedure and further recommend that the phytoplankton suspension be taken from the site being monitored so that the species producing the fluorescence in the standard are as close as possible to the field organisms. To truly assess data reliability in a long term monitoring study, grab samples should be taken periodically, e.g. weekly, and analyzed in the laboratory as the study progresses. These data can then be used to "postcalibrate" the readings logged to the instrument during the study, perhaps using a spreadsheet for the simple mathematical treatment. In any case, getting quantitative chlorophyll data from any *in vivo* fluorometric sensor is much more difficult than with most other environmental sensors. For this reason, it is difficult to provide an accuracy specification for chlorophyll measurement made with *in vivo* fluorometers and therefore no accuracy specification is quoted for the YSI 6025.

EFFECT OF CELL STRUCTURE, PARTICLE SIZE, AND ORGANISM TYPE ON *IN VIVO* READINGS: Even if the only fluorescent species present for *in vivo* measurements were chlorophyll, and reliable calibration standards were available, its absolute quantification would probably still be difficult because samples are not homogeneous. Differing species of algae with differing shape and size will likely fluoresce differently even if the type and concentration of chlorophyll are identical and this significantly limits the accuracy of *in vivo* measurements.

EFFECT OF TEMPERATURE ON PHYTOPLANKTON FLUORESCENCE: As noted above, YSI experiments indicate that phytoplankton fluorescence increases as temperature decreases. Thus, readings taken on a phytoplankton suspension at cold temperature would erroneously indicate the presence of more phytoplankton than when the suspension is read at room temperature. Unless this effect is taken into account, most field readings will be somewhat in error, since the field temperature will differ from the temperature of calibration. The use of the "Chl Tempco" factor found in the Advanced|Sensor menu will help to reduce this error, but must be used with caution since each species of phytoplankton is likely to have a slightly different temperature dependence.

EFFECT OF LIGHT ON PHYTOPLANKTON FLUORESCENCE: It is well documented in the literature that the fluorescence of chlorophyll resident in phytoplankton can be inhibited by light. This "photoinhibition" is confirmed by empirical data which indicate that, at constant phytoplankton level, the fluorescent signal can change significantly on a diurnal schedule, showing less fluorescence during the day and more fluorescence at night. Data showing this diurnal cycle is shown in **Appendix I, Chlorophyll Measurements**. It is clear that this effect would produce errors in the absolute values of chlorophyll unless it were accounted for by the user.

The chlorophyll section of Standard Methods substantiates these limitations along with application notes that are offered by current fluorometer manufacturers. The limitations result in the realization that any *in vivo* "chlorophyll" sensor will be much less quantitative than any of the other sensors offered for use with our sondes.

MEASUREMENT AND CALIBRATION TIPS

1. For best results, analyze field samples to be used for "calibration" of the sensor as soon as possible after collection.

2. If unusually high or jumpy readings are observed during calibration, it is likely that there are bubbles on the optics. The surface should be cleaned by manually activating the wiper before confirming the calibration.

3. The output of the YSI fluorescence sensor is susceptible not only to the overall phytoplankton concentration in the environmental medium, but also to the size and rate of movement of the suspended particles that pass across the optics on the probe face. Thus, although the phytoplankton

content of an environmental sample may appear to the eye to be relatively stable, the displayed chlorophyll reading can vary significantly depending on the nature of the particles in the optical path at the instant of measurement. In a discrete sample study of environmental water, for example, the variability of the output can be significant. This apparent jumpiness is not observed in dye standards, since these are homogeneous solutions containing no suspended matter.

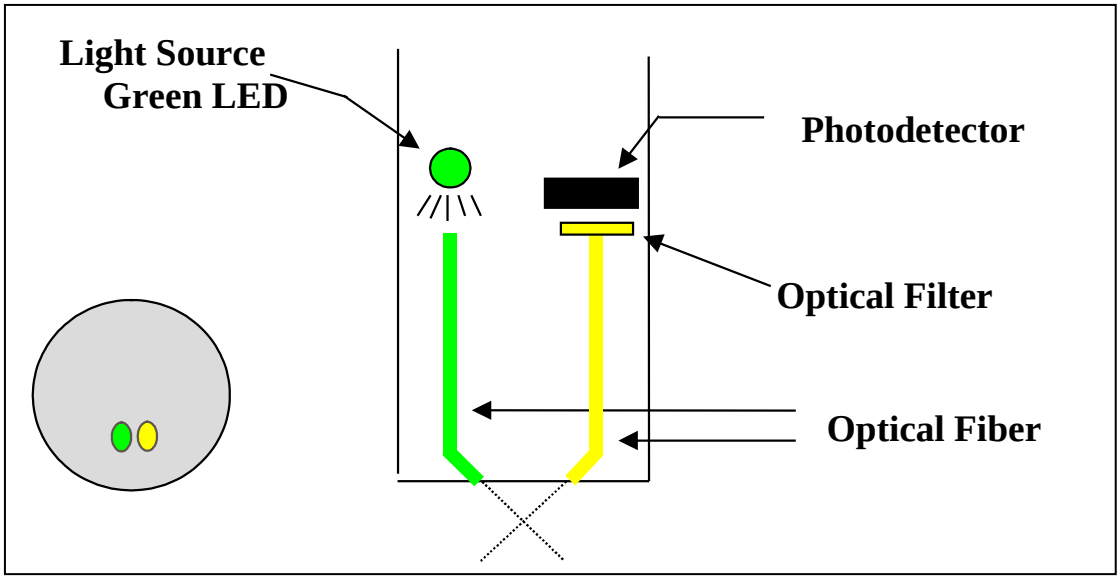
The sonde chlorophyll system allows the user to apply a mathematical filter to the raw data so that the sensor output may be more representative of the average phytoplankton content of the environmental sample. From the **Advanced|Sensor** menu of the sonde software, the user can activate the data filter and adjust its performance. For typical sampling and monitoring applications, YSI recommends that the Data Filter settings for chlorophyll be selected as follows: Enabled -- On; Wait for Filter -- Off; Chlorophyll Time Constant = 12; Chlorophyll Threshold = 1. The advantage of the filter is a more stable display of chlorophyll readings.

5.15 RHODAMINE WT

INTRODUCTION AND PRINCIPLE OF OPERATION

Rhodamine WT is a red dye that is commonly used in stream flow studies. The amount of the species at various points (horizontal and vertical) in the water under examination is determined by utilizing the fact that Rhodamine WT fluoresces when irradiated with the proper wavelength of light and thus the YSI 6130 Rhodamine WT sensor works on the same principles as described above for the 6025 chlorophyll sensor.

As for chlorophyll, Rhodamine WT fluoresces, that is, when irradiated with light of a particular wavelength, it emits light of a higher wavelength (or lower energy). The ability of Rhodamine WT to fluoresce is the basis for all commercial fluorometers capable of measuring the analyte *in situ*. Fluorometers of this type have been in use for some time. These instruments induce Rhodamine WT to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the higher wavelength light which is emitted as a result of the fluorescence process. Most Rhodamine systems use a light emitting diode (LED) as the source of the irradiating light that has a peak wavelength of approximately 540 nm. LEDs with this specification produce radiation in the visible region of the spectrum with the light appearing green to the eye. On irradiation with this green light, Rhodamine WT in the water emits visible light with a higher wavelength than that of the exciting beam, i.e. the Rhodamine fluoresces. To quantify this fluorescence, the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter minimizes (a) the exciting light being detected when it is backscattered off of particles in the water and (b) the interference from other fluorescent species such the chlorophyll in phytoplankton. Without the filter, turbid (cloudy) water or water with high levels of phytoplankton would appear to contain Rhodamine WT, even though none were present. The following diagram can be used to better understand the principles of the YSI Rhodamine WT system.



Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can generally be removed in short term sampling application by simply agitating the sonde manually. However, for studies longer than a few hours where the user is not present at the site, the quality of the data obtained with a Rhodamine WT sensor that has no capability of mechanical cleaning may be compromised. Like all YSI optical probes described above, the 6130 Rhodamine WT probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically during long term unattended sampling studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde software. Generally one movement is sufficient for most environmental application, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

CALIBRATION AND EFFECT OF TEMPERATURE

The sonde software offers the option of 1 point, 2 point, or 3 point calibrations procedures. For most applications, a 2-point calibration at 0 and 100 ug/L is sufficient. However, for maximum accuracy over the entire 0-200 ug/L range of the sensor, a 3-point calibration procedure can slightly enhance the accuracy of the sensor. Note that YSI does not offer Rhodamine WT standards, but does suggest a vendor for user-production of standards and, later in this section, provides instructions for preparing a solution which is 100 ug/L in Rhodamine WT.

While the effect of temperature on the Rhodamine sensor and electronics is small, the fluorescence of Rhodamine WT changes significantly with temperature. The combination of the two factors is automatically taken into account by the sonde software providing temperature compensated readings.

RHODAMINE WT STANDARD SOLUTION – PREPARATION AND USE

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

PREPARATION

Use the following procedure to prepare a 100 ug/L solution that can be used to calibrate your Rhodamine WT sensor for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 1.0 mL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 100 ug/L (0.10 mg/L) in water (a 1000:1 dilution of the concentrated solution).

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

EFFECT OF TURBIDITY ON RHODAMINE WT READINGS

As described above, the filters in front of the photodiode in the YSI 6130 Rhodamine probe prevent most of the green light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on Rhodamine WT readings from suspended solids may result. Laboratory experiments indicate that a suspension of typical soil measured with a turbidity sensor will have turbidity interference characterized by a factor of about 0.03 µg/L per NTU. For example, the turbidity of the water must be above 100 NTU to produce an apparent Rhodamine WT reading equal to 3 µg/L. In very cloudy water, the user may wish to use the independently-determined turbidity value and the above compensation factor to correct measured chlorophyll values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON RHODAMINE WT READINGS

While the green LED used in the Rhodamine WT sensor is not ideal for excitation of the chlorophyll in phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the Rhodamine sensor. Because the filter system for the Rhodamine photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on Rhodamine WT readings from phytoplankton may result. Laboratory

experiments indicate that a suspension of phytoplankton measured with a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 0.10 µg/L Rhodamine WT per ug/L of chlorophyll. For example, the chlorophyll content of the water must be above 30 ug/L chlorophyll to produce an apparent Rhodamine WT reading equal to 3 µg/L. In water with a high algal content, the user may wish to use the independently-determined chlorophyll value and the above compensation factor to correct measured Rhodamine values using, for example, a spreadsheet.

5.16 PHYCOCYANIN-CONTAINING BLUE-GREEN ALGAE

Introduction

Blue-green algae (BGA), also known as cyanobacteria, are common forms of photosynthetic bacteria present in most freshwater and marine environments. BGA contain a unique set of accessory pigments of the phycobiliprotein family that serve a variety of roles for the organism. The primary phycobilin pigments are phycocyanin (PC) and phycoerythrin (PE) and both happen to have strong fluorescent signatures that do not interfere significantly with the fluorescence of the chlorophylls. This allows for the *in vivo* detection of cyanobacteria with minimal interference from other groups of algae. BGA with the PC phycobilin pigment can be found in both fresh and brackish water environments while BGA with the PE phycobilin pigment is usually found only in brackish or marine environments.

The monitoring of BGA is of growing interest in a number of research and monitoring fields and of particular interest is the monitoring of BGA as a public health risk in freshwater and estuarine areas. As the rates of eutrophication accelerate due to human impacts on aquatic ecosystems, algal blooms are becoming a more common problem. In the case of BGA blooms, some species can produce toxins generally referred to as cyanotoxins that can cause health risks to humans and animals. The real-time monitoring of BGA through fluorometry can serve as an early warning system for potentially hazardous conditions. In addition to potential toxin production, BGA blooms can also result in water with an unpleasant appearance, and in the case of drinking water, an unpleasant taste and odor. These problems adversely affect water quality and diminish the water's recreational utility. Also of concern are high cell concentrations causing an increase in filter run times in drinking water plants. Thus, monitoring the BGA population and distribution in lakes, reservoirs and estuarine areas is extremely important for basic research, resource protection, and public health and safety.

The YSI 6131 sensor, when used in conjunction with YSI 6-series multiparameter sondes, is designed to detect and monitor the presence of PC-containing BGA in order to eliminate, or at least reduce, their public health risks and their general effects on drinking water purification.

The determination of BGA as an indicator of water quality has historically been carried out using either (a) extraction of BGA samples followed by analysis of the extracts by fluorometry, HPLC, or a combination of the two techniques or (b) the automated or manual counting of actual BGA cells in the known volume of sample water. While accurate, these types of analytical techniques usually are done as part of a “spot sampling” protocol and almost never yield continuous data with regard to BGA content. The methods are time-consuming and usually require an experienced, efficient analyst to generate consistently accurate and reproducible results. Most importantly, the methods do not lend themselves readily to continuous monitoring of PC-containing BGA, since the analysis of a collection of samples taken at reasonable time intervals, e.g., every hour, would be extremely tedious.

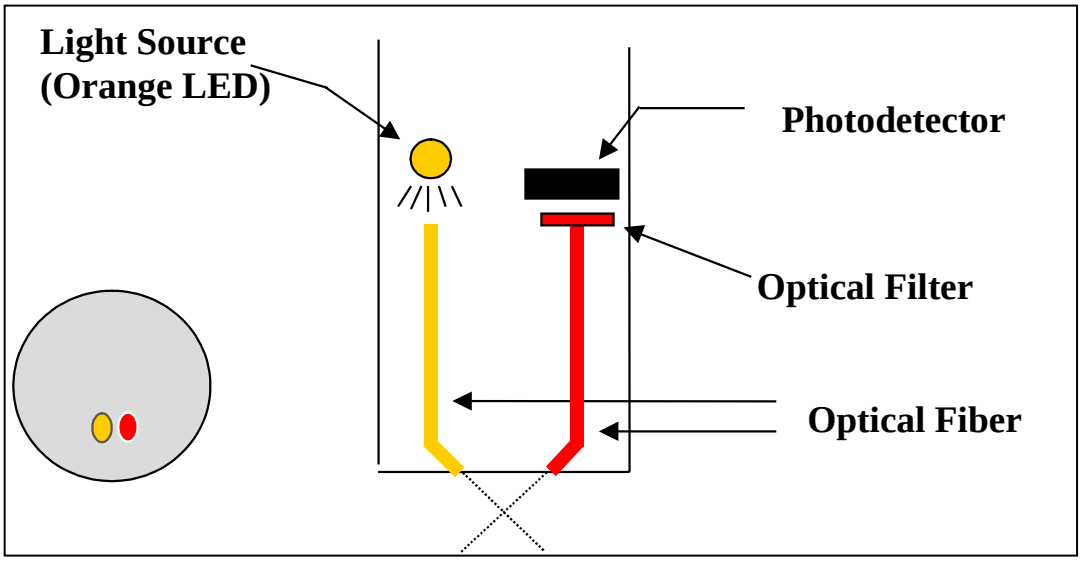
YSI has developed the YSI 6131 sensor for the determination of PC-containing BGA in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of BGA which overcomes the disadvantages of discrete laboratory methods outlined above, albeit with the potential loss of accuracy. In this procedure, PC-containing BGA are measured *in vivo,* i.e., without either disrupting the cells as in the laboratory extractive analysis procedure or using cell counting techniques as

described above. The YSI 6131 sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will almost certainly not be as accurate as those from the certified extractive analytical or cell counting procedures.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making BGA determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6131 with data from standard laboratory analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the estimates of BGA concentration from the easy-to-use YSI Phycocyanin Probe are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of BGA determination. The YSI 6131 sensor is ideally suited for the monitoring the relative changes (temporally or spatially) in the PC-containing BGA population.

Measurement of PC-containing BGA *In Vivo*

One key characteristic of phycocyanin-containing BGA is that the cells fluoresce, that is, when irradiated with light of a particular wavelength, they emit light of a higher wavelength (or lower energy). The ability of phycocyanin to fluoresce while present in whole BGA cells is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. These instruments induce phycocyanin to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the longer wavelength light which is emitted as a result of the fluorescence process. The YSI 6131 Phycocyanin Probe uses an orange light emitting diode (LED) for the excitation process. On irradiation with this orange light, phycocyanin molecules resident in whole cells emit light in the 600-700 nm region of the spectrum. To quantify the fluorescence, the system detector is a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the orange exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain significant amounts of PC-containing BGA, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



The unique YSI 6131 BGA system consists of a probe which is compatible with the optical probe ports of all YSI 6-series sondes. The output of the sensor is automatically processed via the sonde firmware to provide readings in either generic fluorescence units (RFU) or cells/mL of PC-containing BGA. Like all YSI optical probes, the 6131is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With this feature, the YSI 6131 sensor can be deployed in environmental water for several weeks without the need for service and is ideal for providing continuous monitoring of potentially-hazardous PC-containing BGA.

CALIBRATION METHODS

For calibration of the YSI BBA-PC Probe, **only one type of standard will assure the best possible accuracy for field readings: a suspension of known PC-containing BGA cells**. The BGA concentration of this suspension should be determined by either cell counting or a pigment extraction of PC . However, most users may not have cultures of BGA available prior to field studies for use in the 2-point calibration protocol resident in the sonde firmware and thus the best "calibration" method usually comprises the following steps:

1. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 cells/mL
2. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
3. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
4. Collect and transport your field sample according to Standard Methods to ensure the BGA cells contained in the sample are not damaged or significantly changed since the time of collection.
5. On return to the laboratory, analyze the grab samples for the amount of PC-containing BGA and record the results for later use.
6. After the study is complete, place your YSI BGA-PC data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or 'postcalibration") of your field results into more accurate values.
7. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6131 data.

A variation of this method is to perform a 2-point calibration prior to deployment using a clear water and a dye standard, setting the apparent PC-containing BGA equivalent of the dye standard to the value shown in the table in the next section . However, it must be emphasized that this technique does not increase the accuracy of the PC sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab samples and perform laboratory analysis to be assured of meaningful BGA-PC values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF RHODAMINE WT SOLUTIONS FOR CHECKING SENSOR DRIFT

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

Use the following procedure to prepare a 100 ug/L solution that can be used to "calibrate" your YSI 6131 Phycocyanin Probe for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. Mix well. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 1.0 mL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 100 ug/L (0.10 mg/L) in water (a 1000:1 dilution of the concentrated solution).

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when "calibrating" the YSI PC sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The "PC tempco" factor in the Advanced|Sensor menu MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate PC-containing equivalent of 100 ug/L Rhodamine WT as a function of temperature.

T, C	Cells/mL to Enter	T, C	Cells/mL to Enter
30	44940	18	76580
28	49700	16	83580
26	54600	14	91420
24	58940	12	98140
22	64120	10	107940
20	70000	8	113540

REMEMBER: The use of Rhodamine WT for "calibration" of the Phycocyanin Probe is only an approximation. To assure the maximum accuracy for the 6131 sensor, the user must relate the field fluorescence readings to data from actual BGA samples as described above. YSI does not provide an accuracy specification for the sensor due to the limitations described above and below.

EFFECT OF TURBIDITY ON BGA-PC READINGS

As described above, the filters in front of the photodiode in the YSI 6131 Phycocyanin Probe prevent most of the orange light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on PC-containing BGA readings from suspended solids will result. Laboratory experiments indicate that a YSI 6131 sensor will have a turbidity interference characterized by a factor of about 21 cells/mL of PC-containing BGA per NTU of turbidity. For example, at a turbidity of 100 NTU, a PC-containing BGA reading of 2100 cell/mL will be observed over and above the reading actually due to the presence of BGA. Users may wish to use the independently-determined turbidity value and the above compensation factor to correct measured PC-containing BGA values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON BGA-PC READINGS

While the orange LED used in the 6131 Phycocyanin Probe is not ideal for excitation of the chlorophyll in non-BGA phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the Phycocyanin Probe. Because the filter system for the 6131photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on PC-containing BGA readings from chlorophyll-containing phytoplankton will result. Laboratory experiments indicate that a suspension of phytoplankton from *Scenedesmus quadricauda* which had its chlorophyll content measured using a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 77 cells/mL of PC-containing BGA per ug/L of chlorophyll. For example, at a chlorophyll value of 30 ug/L from *Scenedesmus quadricauda*, a PC-containing BGA reading of 2310 cell/mL will be observed over and above the reading actually due to the presence of BGA. Note, however, that the chlorophyll interferences from other algae species are likely to be significantly different from that used in the test, and so the quoted value of 77 cells/mL per ug/L of chlorophyll is only a gross approximation.

EFFECT OF TEMPERATURE ON BGA-PC READINGS

YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence, both due to a change in BGA fluorescence and to a change in probe output. In the absence of compensation, this effect would obviously result in errors in field PC-containing BGA readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a phycocyanin temperature compensation routine ("PC tempco") resident in the sonde firmware under the **Advanced|Sensor** menu where the factor in "% per degree C" can be input by the user.

The value of this factor can be estimated as follows using a single suspension of PC-containing BGA under laboratory conditions. In the experiment, the cells/mL value of the suspension is measured at both ambient temperature and then at a much colder temperature by cooling the suspension in a refrigerator.

Change in Temperature = 21 C at ambient temperature – 2 C in refrigerator = 19 C temperature change
Change in Fluorescence = 100,000 cells/mL at 21 C – 120,000 cells/ml at 2 C = 20,000 cells/mL change
% Change in Fluorescence = (20,000/100,000) x 100 = 20%
PC Tempco Factor = 20%/19 C = 1.05 % per degree °C

CAUTION: This example is hypothetical only. Actual tempco factor values must be determined by the user.

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of PC-containing BGA is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with standards of known BGA composition that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON BGA-PC READINGS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde or by manually activating the wiper. For studies longer than a few hours where the user is not present at the site, the quality of the PC data obtained with a fluorescence sensor that has no

capability of mechanical cleaning is likely to be compromised. The YSI 6131 probe is equipped with a mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde firmware. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

LIMITATIONS OF ACCURACY FOR THE BGA-PC SENSOR

As mentioned above, the measurement of PC-containing BGA from *in vivo* fluorescence measurements will almost always be less accurate than determinations made using either cell counting or spectrofluorometric quantitation of molecular phycocyanin after its extraction from cells. Some of the reasons for this accuracy limitation with *in vivo* BGA-PC measurement include the following:

- Interferences from other microbiological species such as chlorophyll-containing phytoplankton
- Interference from sample turbidity.
- Differences in the general fluorescence intensity of different PC-containing BGA species
- Differences in the effect of temperature on the fluorescence intensity of different PC-containing BGA species
- Effect of the variation in ambient light conditions on BGA fluorescence and differences in this effect between different PC-containing BGA species.

In addition, when present in high concentrations, colonies of BGA can often be seen with the naked eye and may resemble fine grass cutting or take the form of small irregular clumps or pinhead-sized spheres. When BGA colonize into these forms, the sensitivity of the YSI sensor in terms of the fluorescence per cell of BGA is reduced because it has been designed to detect microscopic, free-floating cells and not large, macroscopic floating particles. Thus, the sensor is likely to underestimate the total amount of BGA present in the water when clumps are present.

Users should take careful note that these limitations mean that any *in vivo* sensors such as BGA-PC and chlorophyll will be significantly less quantitative than any of the other sensors offered for use with YSI 6-series sondes and make it impossible for YSI to provide an actual accuracy specification in cells/mL for the 6131 Phycocyanin Probe.

ESTIMATION OF THE BGA-PC RANGE IN CELLS/ML

As noted in the above section, the use of *in vivo* phycocyanin fluorescence to estimate the cell content of PC-containing algae has significant limitations. These limitations also make the designation of a range (or full scale sensor reading) for any PC-BGA sensor less than quantitative. The range estimate for the YSI 6131 sensor is based on the fact that its reading in an empirical sample of PC-containing algae is about 40% less than that of the industry standard fluorometer from Turner Designs which is configured for PC-BGA. In the estimation experiment, a Turner Cyclops sensor was fixed on its middle range and then its voltage reading in a PC-BGA culture (*Microcystis aeruginosa*) was determined. The YSI 6131 sensor was placed in the same culture and its sensitivity found to be about 40% less in terms of the percent of full scale deflection relative to the Turner sensor on its middle range. Since Turner Designs has designated the middle range of its sensor as 0-200,000 cells/mL, the YSI sensor is estimated to have a range of about 40% more or 280,000 cells/mL. Naturally, this range is only an estimation for both the YSI and Turner sensors because of the general limitations of *in vivo* fluorescence measurements described above.

5.17 PHYCOERYTHRIN-CONTAINING BLUE-GREEN ALGAE

Introduction

Blue-green algae (BGA), also known as cyanobacteria, are common forms of photosynthetic bacteria present in most freshwater and marine systems. BGA contain a unique set of accessory pigments of the phycobiliprotein family that serve a variety of roles for the organism. The primary phycobilin pigments are phycocyanin (PC) and phycoerythrin (PE) and both happen to have strong fluorescent signatures that do not interfere significantly with the fluorescence of the chlorophylls. This allows for the *in vivo* detection of BGA with minimal interference from other groups of algae. BGA with the PC phycobilin pigment can be found in both fresh and brackish water environments while BGA with the PE phycobilin pigment is usually found only in brackish or marine environments.

The monitoring of BGA is of growing interest in a number of research and monitoring fields and of particular interest is the monitoring of BGA as a public health risk in coastal areas and as an important primary producer is some oceanic environments. As the rates of eutrophication accelerate due to human impacts on aquatic ecosystems, harmful algal blooms (HABs) are becoming a more common problem. In the case of cyanobacterial blooms, some species can produce toxins generally referred to as cyanotoxins that can cause health risks to humans and animals.

The YSI 6132 sensor, when used in conjunction with YSI 6-series multiparameter sondes, is designed to detect and monitor the presence of PE-containing BGA in order provide an early warning system for potentially hazardous conditions as well as thoroughly characterize aquatic environments where PE-containing BGA exist.

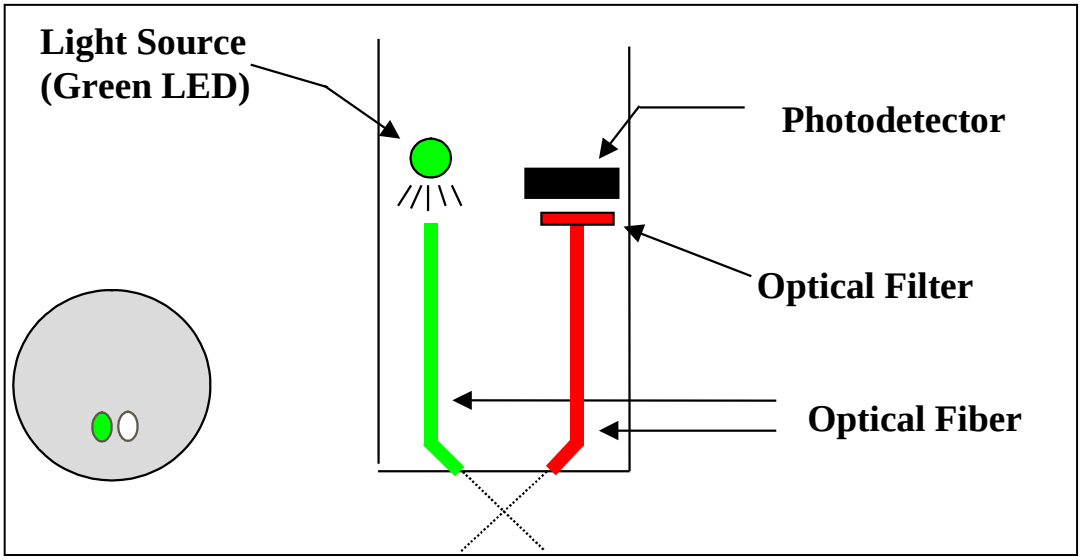
The determination of BGA as an indicator of water quality has historically been carried out using either (a) extraction of BGA samples followed by analysis of the extracts by fluorometry, HPLC, or a combination of the two techniques or (b) the automated or manual counting of actual BGA cells in the known volume of sample water. While accurate, these types of analytical techniques usually are done as part of a "spot sampling" protocol and almost never yield continuous data with regard to BGA content. The methods are time-consuming and usually require an experienced, efficient analyst to generate consistently accurate and reproducible results. Most importantly, the methods do not lend themselves readily to continuous monitoring of PE-containing BGA, since the analysis of a collection of samples taken at reasonable time intervals, e.g., every hour, would be extremely tedious.

YSI has developed the YSI 6132 sensor for the determination of PE-containing BGA in spot sampling and continuous monitoring applications. It is based on an alternative method for the measurement of BGA in general which overcomes the disadvantages of discrete laboratory methods outlined above, albeit with the potential loss of accuracy. In this procedure, PE-containing BGA are measured *in vivo,* i.e., without either disrupting the cells as in the laboratory extractive analysis procedure or using cell counting techniques as described above. The YSI 6132 sensor is designed for these *in vivo* applications and its use allows the facile collection of large quantities of data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of *in vivo* analysis will almost certainly not be as accurate as those from the certified extractive analytical or cell counting procedures.

The limitations of the *in vivo* method are outlined below and should be carefully considered before making BGA determinations with your YSI sonde and sensor. Some of the sources of inaccuracy can be minimized by combining the data from the YSI 6132 with data from standard laboratory analysis of a few samples acquired during a sampling or monitoring study. However, the *in vivo* studies will never replace the standard procedure. Rather, the estimates of BGA concentration from the easy-to-use YSI PE Probe are designed to complement the more accurate (but more difficult to obtain) results from more traditional methods of BGA determination. The YSI 6132 sensor is ideally suited for the monitoring the relative changes (temporally or spatially) in the PE-containing BGA population.

Measurement of PE-containing BGA *In Vivo*

One key characteristic of phycoerythrin-containing BGA is that the cells fluoresce, that is, when irradiated with light of a particular wavelength, they emit light of a higher wavelength (or lower energy). The ability of PE to fluoresce while present in whole BGA cells is the basis for all commercial fluorometers capable of measuring the analyte *in vivo*. These instruments induce PE to fluoresce by shining a beam of light of the proper wavelength into the sample, and then measuring the longer wavelength light which is emitted as a result of the fluorescence process. The YSI 6132 PE Probe uses a green light emitting diode (LED) for the excitation process. On irradiation with this green light, PE molecules resident in whole cells emit light in the 565-610 nm region of the spectrum. To quantify the fluorescence, the system detector is usually a photodiode of high sensitivity that is screened by an optical filter that restricts the detected light. The filter prevents the green exciting light from being detected when it is backscattered off of particles in the water. Without the filter, turbid (cloudy) water would appear to contain significant amounts of PE-containing BGA, even though none were present. The following diagram can be used to better understand the principles of the YSI system.



The unique YSI 6132 BGA system consists of a probe which is compatible with the optical probe ports of all YSI 6-series sondes. The output of the sensor is automatically processed via the sonde firmware to provide readings in either generic fluorescence units (RFU) or cells/mL of PE-containing BGA. Like all YSI optical probes, the 6132 is equipped with a mechanical wiper to periodically clean the optical face either by manual or automatic activation. With this feature, the YSI 6132 sensor can be deployed in environmental water for several weeks without the need for service and is ideal for providing continuous monitoring of potentially-hazardous PE-containing BGA.

CALIBRATION METHODS

For calibration of the YSI BGA-PE Probe, **only one type of standard will assure the best possible accuracy for field readings: a suspension of known PE-containing BGA cells**. The BGA concentration of this suspension should be determined by either cell counting or a pigment extraction of PE. However, most users may not have cultures of BGA available prior to field studies for use in the 2-point calibration protocol resident in the sonde firmware and thus the best "calibration" method usually comprises the following steps:

8. Prior to use in the field, place the sensor in clean water and perform a 1-point calibration at 0 cells/mL
9. Immerse the sonde in a dye standard (see below) and record the reading. Note that you are not "calibrating" to the dye reading, only checking its value relative to the default sensitivity of the sensor.
10. While making your field readings (sampling or unattended studies), collect a few grab samples and record the date/time and location where they were acquired.
11. Collect and transport your field sample according to Standard Methods to ensure the BGA cells contained in the sample are not damaged or significantly changed since the time of collection.
12. On return to the laboratory, analyze the grab samples for the amount of PE-containing BGA and record the results for later use.
13. After the study is complete, place your YSI BGA-PE data in the column of a spreadsheet and place your laboratory data in an adjacent column for comparison. Calculate ratios of field to laboratory results for each grab sample point and then average the results to produce a ratio for adjustment (or 'postcalibration") of your field results into more accurate values.
14. Use the calculating power of the spreadsheet to multiply all of your field readings by the correction ratio to obtain the best possible accuracy for your 6132 data.

A variation of this method is to perform a 2-point calibration prior to deployment using a clear water and a dye standard, setting the apparent PE-containing BGA equivalent of the dye standard to the value shown in the table in the next section . However, it must be emphasized that this technique does not increase the accuracy of the PE sensor significantly over the simple 1-point calibration recommended above – the user still must collect grab samples and perform laboratory analysis to be assured of meaningful BGA-PE values. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

PREPARATION OF RHODAMINE WT SOLUTIONS FOR CHECKING SENSOR DRIFT

***CAUTION*: Before using concentrated Rhodamine WT solution to prepare standards, be certain to read the safety instructions provided by the supplier with this chemical. Remember that only trained personnel should handle chemicals.**

Use the following procedure to prepare an 8 ug/L solution that can be used to "calibrate" your YSI 6132 PE Probe for field use:

1. We recommend that Rhodamine WT concentrate be purchased from Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago, IL 60612 (Telephone: 312-666-2015) under the name KEYACID RHODAMINE WT LIQUID (Part # 70301027). As purchased, the solution is approximately 20 % Rhodamine WT by weight, i.e., 200 g/L.

2. Accurately weigh 0.500 g of the 20 % Rhodamine concentrate, quantitatively transfer the viscous liquid to a 1000-mL volumetric flask and fill the flask to the top graduation. Mix well. This solution contains 100 mg of Rhodamine WT per 1000 mL of water.

3. Accurately transfer 80 uL of the solution prepared in the above step to a 1000 mL volumetric and then fill the flask to the top graduation with purified water. Mix well to obtain a solution that is 8 ug/L (0.008 mg/L) in water.

4. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of its preparation.

When Rhodamine WT standards are required in the future, perform another dilution of the concentrated dye solution after warming it to ambient temperature. Our experience has indicated that the concentrated solution that has been kept at cold temperatures is much more stable than the dilute solution stored at room temperature.

It is well known that the intensity of the fluorescence of many dyes shows an inverse relationship with temperature. The effect must also be accounted for when "calibrating" the YSI BGA-PE sensor with Rhodamine WT. Enter the calibration value from the table below corresponding to the temperature of the standard.

WARNING: The "PE tempco" factor in the Advanced|Sensor menu MUST BE SET TO ZERO, when calibrating with Rhodamine WT.

Table. Approximate PE-containing equivalent of 8 ug/L Rhodamine WT as a function of temperature.

T, C	Cells/mL to Enter	T, C	Cells/mL to Enter
30	156,000	18	210,000
28	164,000	16	220,000
26	174,000	14	230,000
24	181,000	12	240,000
22	189,000	10	247,000
20	200,000	8	254,000

REMEMBER: The use of Rhodamine WT for "calibration" of the PE Probe is only an approximation. To assure the maximum accuracy for the 6132 sensor, the user must relate the field fluorescence readings to data from actual BGA samples as described above. YSI does not provide an accuracy specification for the sensor due to the limitations described above and below.

EFFECT OF TURBIDITY ON BGA-PE READINGS

As described above, the filters in front of the photodiode in the YSI 6132 PE Probe prevent most of the orange light which is used to excite the Rhodamine molecules from reaching the detector after being backscattered off of non-fluorescent particles (turbidity) in environmental water. However, the filter system is not perfect and a minor interference on PE-containing BGA readings from suspended solids will result. Laboratory experiments indicate that a YSI 6132 sensor will have a turbidity interference characterized by a factor of about 140 cells/mL of PC-containing BGA per NTU of turbidity. For example, at a turbidity of 100 NTU, a PE-containing BGA reading of 14000 cell/mL will be observed over and above the reading actually due to the presence of BGA. Users may wish to use the independently-determined turbidity value and the above compensation factor to correct measured PE-containing BGA values using, for example, a spreadsheet.

EFFECT OF CHLOROPHYLL ON BGA-PE READINGS

While the orange LED used in the 6132 PE Probe is not ideal for excitation of the chlorophyll in non-BGA phytoplankton, some fluorescence of environmental chlorophyll will always be induced by the `PE Probe. Because the filter system for the 6132 photodiode is not perfect in excluding chlorophyll fluorescence, a minor interference on PE-containing BGA readings from chlorophyll-containing phytoplankton will result. Laboratory experiments indicate that a suspension of phytoplankton from *Scenedesmus quadricauda* which had its chlorophyll content measured with a YSI 6025 sensor will have chlorophyll interference characterized by a factor of about 20 cells/mL of PC-containing BGA per ug/L of chlorophyll. For example, at a chlorophyll value of 30 ug/L from *Scenedesmus quadricauda,* a PC-containing BGA reading of 600 cells/mL will be observed over and above the reading actually due to the presence of BGA. Note, however, that the chlorophyll interferences from other algae species are likely to be significantly different from that used in the test, and so the quoted value of 20 cells/mL per ug/L of chlorophyll is only a gross approximation.

EFFECT OF TEMPERATURE ON BGA-PE READINGS

YSI experiments have indicated that the fluorescence of phytoplankton suspensions can show significant temperature dependence, both due to a change in BGA fluorescence and to a change in probe output. In the absence of compensation, this effect would obviously result in errors in field PE-containing BGA readings if the site temperature were significantly different from the calibration temperature. This temperature error can be reduced by employing a PE temperature compensation routine ("PE tempco") resident in the sonde firmware under the **Advanced|Sensor** menu where the factor in "% per degree C" can be input by the user.

The value of this factor can be estimated as follows using a single suspension of PE-containing BGA under laboratory conditions. In the experiment, the cells/mL value of the suspension is measured at both ambient temperature and then at a much colder temperature by cooling the suspension in a refrigerator.

Change in Temperature = 21 C at ambient temperature – 2 C in refrigerator = 19 C temperature change
Change in Fluorescence = 100,000 cells/mL at 21 C – 120,000 cells/ml at 2 C = 20,000 cells/mL change
% Change in Fluorescence = (20,000/100,000) x 100 = 20%
PE Tempco Factor = 20%/19 C = 1.05 % per degree °C

CAUTION: This example is hypothetical only. Actual tempco factor values must be determined by the user.

Note that the use of this empirically derived compensation does not guarantee accurate field readings since each species of PE-containing BGA is likely to be unique with regard to the temperature dependence of its fluorescence. Changes in fluorescence with temperature are a key limitation of the *in vivo* fluorometric method (see below) which can only be reduced, not eliminated, by this compensation. In general, the best way to minimize errors is to calibrate with standards of known BGA composition that are as close as possible in temperature to that of the environmental water under investigation.

EFFECT OF FOULING ON BGA-PE READINGS

Field optical measurements are particularly susceptible to fouling, not only from long term build up of biological and chemical debris, but also to shorter term formation of bubbles from outgassing of the environmental water. These bubbles can sometimes be removed in short term sampling applications by simply agitating the sonde or by manually activating the wiper. For studies longer than a few hours where the user is not present at the site, the quality of the PE data obtained with a fluorescence sensor that has no capability of mechanical cleaning is likely to be compromised. The YSI 6132 probe is equipped with a

mechanical wiper that makes it ideal for unattended applications. The wiper can be activated in real-time during discrete sampling operations or will function automatically just before each sample is taken during long term unattended monitoring studies. The number of wiper movements and the frequency of the cleaning cycle for the unattended mode can be set in the sonde firmware. Generally, one wiper movement is sufficient for most environmental applications, but in media with particularly heavy fouling, additional cleaning cycles may be necessary.

LIMITATIONS OF ACCURACY FOR THE BGA-PE SENSOR

As mentioned above, the measurement of PE-containing BGA from *in vivo* fluorescence measurements will almost always be less accurate than determinations made using either cell counting or spectrofluorometric quantitation of molecular PE after its extraction from cells. Some of the reasons for this accuracy limitation with *in vivo* BGA-PE measurement include the following:

- Interferences from other microbiological species such as chlorophyll-containing phytoplankton
- Interference from sample turbidity.
- Differences in the general fluorescence intensity of different PE-containing BGA species
- Differences in the effect of temperature on the fluorescence intensity of different PE-containing BGA species
- Effect of the variation in ambient light conditions on BGA fluorescence and differences in this effect between different PE-containing BGA species.

In addition, when present in high concentrations, colonies of BGA can often be seen with the naked eye and may resemble fine grass cutting or take the form of small irregular clumps or pinhead-sized spheres. When BGA colonize into these forms, the sensitivity of the YSI sensor in terms of the fluorescence per cell of BGA is reduced because it has been designed to detect microscopic, free-floating cells and not large, macroscopic floating particles. Thus, the sensor is likely to underestimate the total amount of BGA present in the water when clumps are present.

Users should take careful note that these limitations mean that any *in vivo* sensors such as BGA-PE and chlorophyll will be significantly less quantitative than any of the other sensors offered for use with YSI sondes and make it impossible for YSI to provide an actual accuracy specification in cells/mL for the 6132 PE Probe.

ESTIMATION OF THE BGA-PE RANGE IN CELLS/ML

As noted in the above section, the use of *in vivo* phycoerythrin fluorescence to estimate the cell content of PE-containing algae has significant limitations. These limitations also make the designation of a range (or full scale sensor reading) for any BGA-PE sensor less than quantitative. The range estimate for the YSI 6132 sensor is based on the fact that its reading in an empirical sample of PE-containing algae is very similar to that of the industry standard fluorometer from Turner Designs which is configured for BGA-PE. In the estimation experiment, the Turner Cyclops was fixed on its middle range and then its voltage reading in a BGA-PE culture (a *Synechococcus* sp.) was determined. The YSI 6132 sensor was placed in the same culture and its sensitivity adjusted to show the same percent of full scale deflection as the Turner sensor on its middle range. Since Turner Designs has designated the middle range of its sensor as 0-200,000 cells/mL, the YSI sensor is estimated to have the same range. Naturally, this range is only an estimation for both the YSI and Turner sensors because of the general limitations of *in vivo* fluorescence measurements described above.

5.18 FLOW

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. YSI sondes that are equipped with shallow vented level can calculate flow based on several different methods.

Flow is only available in the Sensors menu on those sondes that have shallow vented level. The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use our sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly in this manual, it is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

WEIR AND FLUME

Many devices have been designed for the determination of flow in an open channel. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs; each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the channel, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes, each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are commonly 3 types of weirs and 7 types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

MANNING EQUATION

YSI sondes with shallow vented level can be used with the Manning equation. In an open channel without any restriction built explicitly for measuring flow, the Manning Equation can sometimes be used to calculate flow. Under the right conditions the channel itself is the primary measurement device and flow can be calculated from the level of water in the channel. Careful use of the Manning equation under ideal conditions can be accurate to 10%. Less careful use under worse conditions can give errors of 50% or more. The formula is:

$$Q = \frac{K \bullet A \bullet R^{\frac{2}{3}} \bullet S^{\frac{1}{2}}}{n}$$

Where: Q = Flow rate
A = Cross sectional area of flow
R = Hydraulic radius
S = slope
n = Manning coefficient of roughness
K = constant dependent on units

The Manning roughness coefficient n is an index of the frictional resistance to flow on the surface of the channel. Values of n are published for different materials. However, in the field, determination of n is perhaps the largest source of error. For example, n for a concrete channel can vary from 0.011 to 0.020 depending upon how the surface of the concrete was finished during construction. Occasional debris or

vegetation in the channel also affects the value of n, and in most applications the value changes depending upon the depth of water in the channel.

Other uncertainties can also make the measurement inaccurate. Best results are obtained at the end of a straight channel 1000 feet (300 meters) long. However, in reality it is difficult to find channels that are very long, and very straight, and with constant slope, and with uniform roughness.

Even with all these uncertainties, the Manning equation can yield useful results as long as the user is aware of its limitations.

EQUATION

The YSI sondes that are equipped with shallow vented level can also calculate flow based on an equation. The equation must be of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

This allows the use of primary measuring devices other than the standard ones already programmed. Users may enter values for K_1, P_1, K_2, and P_2 and the sonde will calculate flow. Note: if you do not need the second term in the equation, simply enter 0 for K_2.

TABLE

YSI sondes that are equipped with shallow vented level can also calculate flow based on a table. Users can enter up to 50 pairs of (level, flow) data. The sonde will then calculate flow from the resulting table, linearly interpolating between points when necessary. This feature can be used with non-standard primary measuring devices for which there is a table rather than an equation. This data is often available for rivers and streams so that flow can be calculated from the level in a river at the proper location.

See Appendix F, Flow for additional practical information on the calculation of flow with a sonde.

SECTION 6 TROUBLESHOOTING

This section contains troubleshooting tables that will be helpful to identify the causes of the most common difficulties that may occur while operating the YSI 6-Series Sondes. The **Symptom** column describes the type of difficulty that you might experience. The **Possible cause** column describes the conditions that might cause the stated symptom. The **Action** column provides simple steps that can be followed to correct for the "possible cause" and cure the "symptom" being experienced. The column entitled **Ref** is the number of the reference section and subsection in the manual where you may find additional information.

Troubleshooting problems have been categorized into four general areas.

- Calibration Error Messages
- Sonde Communication
- Sensor Performance

If you need assistance that this Troubleshooting section can not provide, please contact YSI Technical Support.

6.1 CALIBRATION ERRORS

There are three main Calibration Error messages that are possible and are listed below, instead of in the troubleshooting table. Only two of the error messages are related to sensor performance.

High DO Charge: This message indicates a malfunction in the Rapid Pulse DO sensor that is generally due to the roughness of the electrodes on the surface of the probe face. The charge associated with the DO sensor must be below 75 or the error message will appear when calibration is attempted. If this error message is encountered, remove the DO probe from the sonde and resurface it according to the instructions in **Section 2.10, Care, Maintenance and Storage**. After resurfacing the probe, activate the DO charge parameter in the Report setup section of the sonde software and confirm that the value is within the acceptable range of 50 ± 25. After resurfacing, allow the sensor to pulse in the Run mode for at least 5 minutes, during which time the DO charge may be expected to drop in value if the sensor is still functional. If resurfacing according to the instructions in **Section 2.10, Care, Maintenance and Storage** does not result in a lowering of the charge, contact YSI Technical Support for additional help.

Out of Range: This message indicates that the output of the sensor being calibrated does not conform to the normal range for this parameter. This problem could be due to either a malfunctioning sensor or to a calibration solution that is out of specification. If this error message is encountered, first insure that your standards for pH, ORP, ammonium, nitrate, chloride, conductivity, and turbidity have not been contaminated and that your DO sensor is in air (DO % Cal) or in a solution of known dissolved oxygen concentration (DO mg/L). Also be certain that you have entered the correct value for the calibration solution. If the calibration error message continues to occur, contact YSI Technical Support to determine whether the sensor in question needs to be factory-serviced or replaced.

Bad Input: This message simply indicates that your keyboard input does not conform to the accepted format for this parameter. For example, you may have entered the “letter O” instead of “zero” for a calibration value. Return to the desired parameter in the Calibrate menu and repeat the calibration entry being certain to enter only numbers.

The following troubleshooting tables can help you if you encounter problems with software, communication protocol, or sensor malfunctions other than calibration errors.

6.2 SONDE COMMUNICATION PROBLEMS

SYMPTOM	POSSIBLE CAUSE	ACTION	REF
Cannot communicate with sonde	Sonde not powered	Check 12 vdc source	2.3.3
	Cable connection is loose	Check both ends of cable; secure connectors	2.3.4
	Damaged connectors	Check pins at both ends; insure they are straight, dry and clean.	
	Com port not selected	Change to other com port, other peripheral on the same port (Internal mouse). Try other PC, 650 display/logger or dumb terminal	2.4.3
Scrambled data	Unmatched baud rate between host and sonde	Match the baud rate	2.4.3
	Host is too slow	Use faster computer	
	Interface cable failure	Check cable for damage. If necessary, return for service	2.3.4
	Internal failure	Return sonde for service	9

6.3 SENSOR PERFORMANCE PROBLEMS

SYMPTOMS	POSSIBLE CAUSE	ACTION	REF
Rapid Pulse dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO cal procedures	2.6.1
	Membrane not properly installed or may be punctured	Follow 6562 setup procedure	2.3.1
	DO probe electrodes require cleaning	Follow DO cleaning procedure. Use 6035 maint. kit	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Algae or other contaminant clinging to DO probe	Rinse DO probe with clean water	2.10.2
	Barometric pressure entry is incorrect	Repeat DO cal procedure	2.6.1
	Cal at extreme temperature	Recal at (or near) sample temperature	2.6.1
	DO Charge too high (>75) 1. Anodes polarized (tarnished) 2. Probe left on continuously	Enable DO charge parameter in the Sonde report menu. Run sonde, if charge is over 100, recondition probe with 6035 Maintenance Kit. Follow DO cleaning procedure.	2.10.2
	DO Charge too low (<25) Insufficient electrolyte.	Replace electrolyte and membrane.	2.3.1
	DO probe has been damaged	Replace 6562 probe	9
	Internal failure	Return sonde for service	9
ROX dissolved Oxygen reading unstable or inaccurate	Probe not properly calibrated	Follow DO cal procedures	2.6.1
	Membrane assembly not properly installed or may be punctured	Follow instructions for proper membrane assembly replacement	2.10.2
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Algae or other contaminant clinging to DO probe	Rinse DO probe with clean water	2.10.2
	Barometric pressure entry is incorrect	Repeat DO cal procedure	2.6.1
	Membrane assembly is more than 1 year old	Replace membrane assembly (6155 Optical DO Membrane Replacement Kit)	9
	Wiper is not parking correctly	Make certain that setscrew is tight. If problem persists, return probe for service.	9
	DO probe has been damaged	Replace 6150 probe	9
pH, ORP, chloride, ammonium, or nitrate readings are unstable or inaccurate. Error messages appear during calibration.	Probe requires cleaning,	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	2.6.1
	pH probe reference junction has dried out from improper storage.	Soak probe in tap water or buffer until readings become stable	2.10.2

	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace probe	9
	Calibration solutions out of spec or contaminated with other solution	Use new calibration solutions	C
	ORP fails Zobell check	Take into account temperature dependence of Zobell solution readings	5.4
	Internal failure	Return sonde for service	9

Depth unstable or inaccurate	Depth sensor has not been zeroed	Follow depth zero procedure	2.6.1
	Depth sensor access hole is obstructed	Follow depth cleaning procedure	2.10.2
	Depth sensor has been damaged	Return sonde for service	9
	Internal failure	Return sonde for service	9
Conductivity unstable or inaccurate. Error messages appear during calibration.	Conductivity improperly calibrated.	Follow cal procedure	2.6.1
	Conductivity probe requires cleaning	Follow cleaning procedure	2.10.2
	Conductivity probe damaged	Replace probe	9
	Calibration solution out of spec or contaminated	Use new calibration solution	C
	Internal failure	Return sonde for service	8
	Calibration solution or sample does not cover entire sensor.	Immerse sensor fully.	2.6.1
Installed probe has no reading	The sensor has been disabled	Enable sensor	2.9.7
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace the 6560 probe	9
	Report output improperly set up	Set up report output	2.9.6
	Internal failure	Return sonde for service.	9
Temperature, unstable or inaccurate	Water in connector	Dry connector; reinstall probe	2.3.2
	Probe has been damaged	Replace the 6560 probe	9
Optical probe (turbidity, chlorophyll, rhodamine WT, BGA-PC, or BGA-PE) unstable or inaccurate. Error messages appear during calibration	Probe requires cleaning.	Follow probe cleaning procedure	2.10.2
	Probe requires calibration	Follow cal procedures	2.6.1
	Probe has been damaged	Replace probe	9
	Water in probe connector	Dry connector; reinstall probe	2.3.2
	Calibration solutions out of spec	Use new calibration solutions	C
	Wiper is not turning or is not synchronized.	Activate wiper. Assure rotation. Make sure setscrew is tight.	2.10.2
	Wiper is fouled or damaged.	Clean or replace wiper.	2.10.2
	Internal failure.	Return probe for service.	9

SECTION 7 COMMUNICATION

This section describes the communication protocols that the Sondes use to communicate with the host system. **Section 7.1** gives a brief overview of the communication ability of the Sondes. The remaining sections describe available hardware and software features.

7.1 OVERVIEW

The sondes communicate via a serial port that can be configured as either a SDI-12, or a 3-wire RS-232 interface. The normal mode of operation for the sonde is RS-232, with the following configurations:

Baud rate: 300, 600, 1200, 2400, 4800, 9600
Data Bit: 8
Parity: None
Handshake: None

For further detail into the sondes RS-232 and SDI-12 implementations, see S**ections 7.3 and 7.4** respectively.

With these configurations, the Sonde is capable of interfacing to a variety of devices from a "dumb" terminal to numerous data collection platforms.

7.2 HARDWARE INTERFACE

Connection from the Sonde to the host computer is provided using the YSI 6095B MS-8 to DB-9 female adapter. This 6095B then connects to the standard DB-9 male connector on the host computer. The Sonde PC interface cable is wired for direct connection to a DTE device. The following table defines the interface circuits. The signals and their directions are defined with respect to use of the Sonde with the 6095B adapter.

Wire Color	Pin Description	DB-9	MS-4	MS-8
Yellow	RS232 TX	2	----	C
Orange	RS232 RX	3	----	D
Green	Alarm	----	----	E
Grey	RTS	----	----	G
Blue	CTS	----	----	H
Red	+ 12V DC	9	A	A
Black	GND	5	C	B
Purple	SDI-12	----	B	F
Bare	Shield	----	----	B

7.3 RS-232 INTERFACE

The sonde has an auto-baud feature that allows the instrument to automatically adjust to the terminal baud rate. If the sonde is set to a baud rate of 4800 and a 9600 baud terminal is attached to it, after a few carriage returns are entered, the sonde will recognize the communication mismatch and attempt to change its own internal baud rate to match the terminals.

7.4 SDI-12 INTERFACE

SDI-12 is an industry-standard serial digital interface bus. The bus was designed to allow compatibility between data collection devices and sensors of various manufacturers. The description below applies specifically to the Sonde implementation of SDI-12 interface. For complete SDI-12 technical specifications please contact:

Campbell Scientific, Inc.
P.O. Box 551
Logan, Utah 84321 USA
(801) 753-2342

SDI-12 is a single master multi-drop bus and command protocol. As many as 10 sensors can be connected to the bus at a time. Each sensor is pre-assigned a unique address from 0 to 9. Each Sonde is factory-set to address 0. The address can be changed in the System menu, **see Section 2.9.5, System menu** for details.

Running the sonde in SDI-12 mode requires it to be connected to a SDI-12 master device. An example of such a device is the YSI 6200 or units from Campbell Scientific or Handar Instruments. These instruments provide the commands necessary to communicate with the sonde in SDI-12 mode. In addition, the sonde also supports the following commands which are entered from the command line at the # prompt:

SDI12

This command activates SDI-12 mode. This is the only mode in which the Sonde will respond to any SDI-12 command. To exit to command line, press any key from the terminal connected to the RS-232 port.

The Sonde implements the basic SDI-12 command set. Below are the descriptions of each command and their responses.

The following notations are used:

a Sonde SDI-12 address (ASCII '0' to '9')

[CR] Carriage return (ASCII 13)

[LF] Line feed (ASCII 10)

Master Any SDI-12 compatible data collection device

```
Master:          aM!        Initiate a measurement.
Sonde:     atttn[CR][LF]
```

`ttt` - Maximum time in seconds the Sonde will take to complete the measurement.

`n` - Number of data that will be available when the measurement is completed. This number is the same as the number of output parameters set in the Report menu, as described in **Section 2.9.6, Report**. For ten or more parameters, the sonde returns ":", ";", "<", "=", ">", "?", "@", "A", "B",…etc.

After finishing the measurement, the Sonde will usually send a service request "a[CR][LF]" to the bus master. The bus master can then retrieve the measurement result by "D0" to "D9" commands (see below). If the Sonde does not send a service request within the specified maximum time, the measurement is canceled. The bus master can then restart with another "M" command.

```
Master:          aI!        Send identification.

Sonde:     allccccccccmmmmmmvvvxxx...xxx[CR][LF]
```

`l` - 2 character SDI-12 level number.

`c` - 8 character manufacturer identification. This field always contains "YSIIWQSG" (YSI Inc., Water Quality Systems Group).

`m` - 6 character model number. This field always contains "EM600_" or "EM 6920" (Environmental Monitoring System Sonde) depending on the sonde.

`v` - 3 character version number. This field holds the sonde's software version number ("100" for version 1.00).

```
Master:          aD0! to aD9!
Retrieve measurement/verifying data

Sonde:     a<values>[CR][LF]
```

<**`values`**>- 33 characters or less. This field holds one or more values resulting from a measurement or verifying sequence. A value contains between 1 to 7 digits with an optional radix mark (period '.' or comma ','). Each value must be preceded by its sign (either '+' or '-') since the sign is also used to delimit multiple values.

If the number of values returned by the "D0" command is less than the number specified in the previous response to "M" commands, the rest of the data can be retrieved by using "D1" to "D9" commands. The "D" commands are non-destructive. Thus if the same "D" command is issued multiple times before the next "M" command, it will return the same data. If the response to the "D0" command is "a[CR][LF]" then either no "M" command was received before the first "D" command or the "M" command was canceled.

Example: Here is an example SDI-12 transaction. Here SDI-12 master will issue an Identify command followed by a Measure command. The sonde is configured with a report output of Temperature, Specific conductance, DO %, DO mg/L, pH (ISE1), ORP (ISE2), and Depth, a DO warm up time of 60 seconds, and an SDI-12 address of 1.

Master: 1I!

Sonde: 110YSIIWQSGEM600_107[CR][LF]

The bus master asked for identification and the Sonde returned data showing the following.

SDI-12 level: 1.0

Manufacturer: YSIIWQSG
Model: EMS600_
Version: 1.07

Master: 1M!

Sonde: 10617[CR][LF]

The bus master sent a measurement command. The Sonde will take a maximum of 61 seconds to finish the measurement. Upon completion, it will have 7 sensor data available.

Sonde: 1[CR][LF]

Master: 1D0!

Sonde: 1+17.5+12.05+98.7+8.25+6.45[CR][LF]

Master: 1D1!

Sonde: 1-325+10[CR][LF]

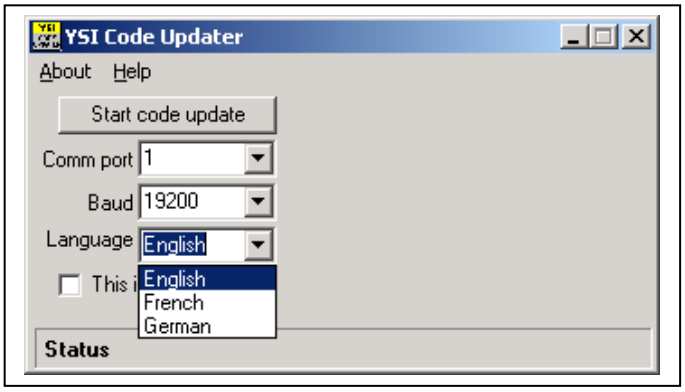
After finishing the measurement, the Sonde sent a service request to indicate completion. The bus master then sent the "D0" command to retrieve the data. There were 5 data returned. Since 7 readings should be available, the master continued with "D1" command and received the remaining data. The responses from "D0" and "D1" commands are:

Temperature:		17.5
Specific conductance:		12.05
DO %:	98.7	
DO mg/L:		8.25
pH (ISE1):		6.45
ORP (ISE2):		-325
Depth:	10	

SECTION 8 UPGRADING SONDE FIRMWARE

YSI periodically makes changes in the firmware which is resident in the sonde and controls its functions. These changes can be made to allow the use of new sensors, to improve the overall capability of the instrument, or to fix problems which have arisen in the existing firmware. New versions of 6-series firmware can easily be installed in the sonde without returning the instrument to the factory. Upgrades are performed from the YSI Website and should be carried according to the following instructions.

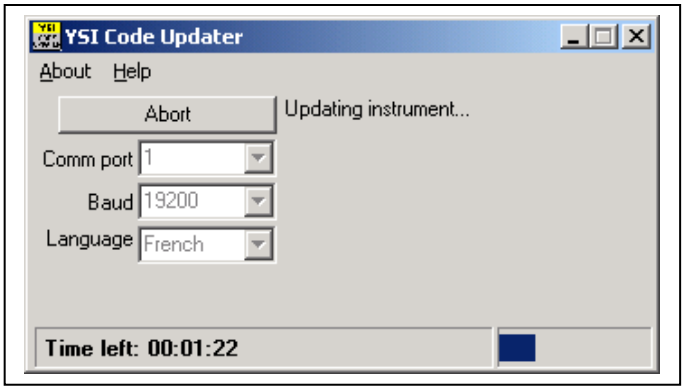
- Connect your sonde to the serial port of a PC with access to the Internet using the proper cable as described in Section 2 of the manual.
- Make sure that the sonde is powered with either internal batteries or a suitable power supply.
- Access the YSI Environmental Software Downloads page at www.ysi.com/edownloads or go to main page at www.ysi.com and click on Support button in green bar.
- Log in, or if a first time user, fill out the registration form and wait for a login password via return E-mail.
- Click on the **Software** folder under the Software Downloads section.
- Inside the folder, click on the file *6-Series & 556MPS Code Updater, M-DD-YYYY* and save the file to a temporary directory on your computer.
- After the download is complete, run the file that you just downloaded and follow the on-screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI Technical Support for advice.
- Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:



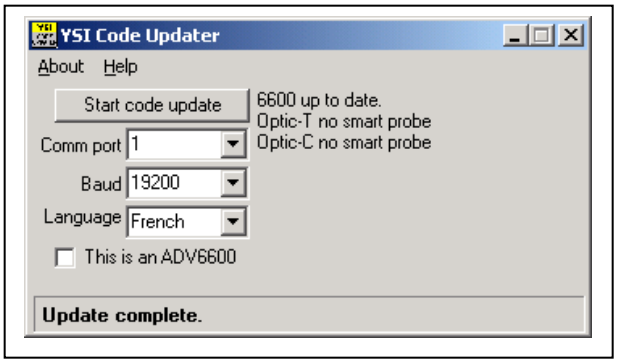
- Set the Comm port number to match the port to which you connected the sonde cable and make sure that the “This is an ADV6600” selection is NOT checked. Next, select the language (English, French, or German) which will be used in the menus of your sonde.

  NOTE CAREFULLY: With versions of 6-series sonde firmware greater than 3.00, you will NOT be able to switch languages in the System Menu of your sonde as in past versions. If you decide to use your sonde with the menus in a different language than that selected at the time of the sonde upgrade, you MUST rerun the YSI Code Updater Software and select the language via the Updater.

- Then click on the Start Code Update button. An indicator bar will show the progress of the upgrade as shown below.



- When the update is finished (indicated on the PC screen as shown below), close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.



SECTION 9 WARRANTY AND SERVICE INFORMATION

The sondes are warranted for two years and the 650 MDS for three years against defects in workmanship and materials when used for their intended purposes and maintained according to instructions. All cables are warranted for one year. The warranty periods for probes are as follows:

- All ROX DO optical probes manufactured on or after April 2006 are covered under the "2-3" plan; 2 year warranty plus reduced repair costs for years 3 through 5. ROX membrane assembly is warranted for 1 year. †
- All non-DO (Turbidity, Chlorophyll, Rhodamine WT, Blue-green Algae – Phycocyanin, and Blue-green Algae – Phycoerythrin) optical probes manufactured on or after August 2006 are covered under the "2-3" plan; 2 year warranty plus reduced repair costs for years 3 through 5. †
- Depth, Rapid Pulse dissolved oxygen, temperature/conductivity, pH, pH/ORP, and chloride probes are warranted for 1 year. Ammonium and nitrate probes are warranted for six months.

† Due to the dynamic nature of the shaft seal used on the optical probes, they must be returned to a YSI repair center on an annual basis for the warranty to be valid and honored if a failure were to occur.

This warranty does not include batteries or damage resulting from defective batteries. As documented in the Care and Maintenance Section of this manual, batteries should be removed from all sondes and the 650 MDS when the product is not in use. Since many battery manufacturers will repair or replace any equipment that has been damaged by their batteries, it is essential that leaky or defective batteries be retained with the damaged product until the manufacturer has evaluated the claim. Please contact the YSI Technical Support Group if you have any questions.

Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Technical Support in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

9.1 LIMITATION OF WARRANTY

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A

PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

9.2 AUTHORIZED SERVICE CENTERS

YSI has several authorized Service Centers in the United States and around the world. Please refer to the YSI website (ysi.com) for you nearest authorized Service Center.

9.3 CLEANING INSTRUCTIONS

NOTE: Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at YSI, the following steps must be taken to insure the safety of our service personnel.

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1-gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.

- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.

- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.

- Any product being returned to the YSI Repair Center should be packed securely to prevent damage.

- Cleaning must be completed and certified on any product before returning it to YSI.

9.4 PACKING INSTRUCTIONS

- Clean and decontaminate items to insure the safety of the handler.
- Complete and include the Product Return Form which is on the next page of this section.
- Place the product in a plastic bag to keep out dirt and packing material.

- ☞ Use a large carton, preferably the original, and surround the product completely with packing material.
- ☞ Insure for the replacement value of the product.

9.5 PRODUCT RETURN FORM

Product Return Form

If known, please provide your:
YSI Customer # _____
Service Request # _____

Step 1: Provide your billing and shipping information

Bill To	Ship To
Contact:	Contact:
Phone: ( )	Phone: ( )
Fax: ( )	Fax: ( )
Email:	Email:

Return Shipping	
Via (circle one)	
DHL FedEx UPS	
Account #:	
Please note: Shipping is prepaid and add.	
Method (circle one)	
Ground	Next Day AM
2 Day	Next Day PM
Other:	

Step 2: Provide information on your equipment

Model Number:	Serial Number:
Please describe the problem(s):	

Step 3: Provide your method of payment

Payment Method For faster service, specify 'Pre-approval', provide the amount and payment method
☐ Pre-approval with Purchase Order (please attach) Amount: _____ PO Number: _____
☐ Credit Card To ensure security, all credit card information must be processed via phone. Please call the service center handling your repair with card information. We accept VISA, MasterCard and American Express.
☐ Prepayment
☐ Quote Required
Please note: There is an estimate fee of approximately $35 to $80 (product dependent) which is waived if service is approved.

Ship to one of the following locations:

YSI Service Center
1725 Brannum Lane
Yellow Springs, OH 45387
+1 937 767 7241
environmental@ysi.com

YSI Service Center
12231 Industriplex Blvd, Suite A
Baton Rouge, LA 70809
+1 225 753 2650
gulfcoast@ysi.com

Step 4: Fill out the Cleaning Certificate

Cleaning Certificate
Model Number:
Lot/Serial Number:
Contaminants (if known):
Cleaning Agents used:
☐ Radioactive Decontamination Certified (check only if product has been exposed to radiation and successfully decontaminated.)
Cleaning Certified by: Signature: X _____ Date: _____

For more information contact your service center or visit www.ysi.com.

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APPENDIX A HEALTH AND SAFETY

NOTE: For additional health, safety, and disposal information about YSI reagents, download the MSDS documents for the chemical in question from the YSI webpage (ysi.com).

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, and 3169

INGREDIENTS:
- Iodine
- Potassium Chloride
- Water

Inhalation:
Inhalation of mist or splashes of iodine solution can cause severe irritation, with potential destruction of respiratory tissues, spasms, and edema (choking) in throat and lungs, depending on frequency and degree of exposure. Other reported potential effects are coughing, burning sensation, laryngitis, headache, and nausea.

Use a NIOSH approved respirator for liquid mists and/or splashes. Get supplier recommendations. Provide adequate ventilation. Avoid conditions that cause misting or splashing.

Remove to fresh air. Give artificial respiration and get medical attention as needed.

Skin:
May cause irritation with repeated exposure.
Wear water-resistant gloves as needed.
Wash exposed areas with soap and water for 15 minutes. Remove contaminated clothing, and wash before re-using.

Eyes:
Can cause irritation and potential eye damage with repeated exposure.
Wear splash-proof water-resistant goggles. Have convenient eyewash stations.
Flush with water for 15 minutes.

Ingestion
Can cause irritation of mouth, throat, and an upset stomach.
Wear a mouth cover or face shield when there is splashing.
Do not swallow. Rinse mouth. If swallowed, do not induce vomiting. Get prompt medical attention.

(No chronic effects reported)

IN ALL CASES: GET MEDICAL ATTENTION IF EFFECTS PERSIST.

Most likely routes of entry: skin, eyes, ingestion.

FIRST AID:

INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.

SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.

EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.

INGESTION: Wash out mouth thoroughly with large quantities of water. Do not induce vomiting. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:
- θ Potassium Hydrogen Phthalate
- θ Formaldehyde
- θ Water

pH 7 INGREDIENTS:
- θ Sodium Phosphate, Dibasic
- θ Potassium Phosphate, Monobasic
- θ Water

pH 10 INGREDIENTS:
- θ Potassium Borate, Tetra
- θ Potassium Carbonate
- θ Potassium Hydroxide
- θ Sodium (di) Ethylenediamine Tetraacetate
- θ Water

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:

- Potassium Chloride
- Potassium Ferrocyanide Trihydrate
- Potassium Ferricyanide

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Ammonium Standard Solutions: 3841, 3842, and 3843

INGREDIENTS:

- Ammonium Chloride
- Lithium Acetate Dihydrate
- Sodium Azide (trace)
- Hydrochloric acid

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities of lithium salts can affect the central nervous system producing symptoms ranging from dizziness to collapse. It may also cause kidney damage, nausea, and anorexia. Note that the ingestion of harmful quantities form the solutions is considered unlikely given the low concentration of lithium and the volumes likely to be handled.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - Immediately rinse out mouth with large quantities of water. If reagent was swallowed, give 2 glasses of water and seek medical attention immediately.

YSI Nitrate Standard Solutions: 3885, 3886, and 3887

INGREDIENTS

- Potassium Nitrate
- Magnesium Sulfate
- Gentamycin Sulfate (Trace)

CAUTION **- AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION.**

May be harmful by ingestion or skin absorption. May cause eye and skin irritation. The chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

INHALATION - Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes).

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - Immediately rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention immediately.

YSI Turbidity Standard: 6073

INGREDIENTS

θ Styrene divinylbenzene copolymer spheres

The material is not volatile and has no known ill effects on skin, eyes, or on ingestion. Therefore, no special precautions are required when using the standards. General precautions should be adopted as required with all materials to minimize unnecessary contact. Note, however, that the chemical, physical, and toxicological properties have not been thoroughly investigated.

FIRST AID:

SKIN CONTACT - Remove contaminated clothing. Wash affected area with soap or mild detergent and water.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. If irritation occurs, seek medical attention immediately.

INGESTION - Rinse out mouth with large quantities of water. If irritation occurs or reagent was swallowed, seek medical attention as a precaution.

YSI Replacement Desiccant 065802

INGREDIENTS

θ Calcium Sulfate and Calcium Chloride

***CAUTION* - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

FIRST AID:

SKIN CONTACT - Flush with water.

EYE CONTACT - Flush with water. If irritation continues, obtain medical attention.

INGESTION - If patient is conscious, induce vomiting. Obtain medical attention.

APPENDIX B REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

APPENDIX C ACCESSORIES AND CALIBRATION STANDARDS

STANDARD EQUIPMENT WITH YSI SONDES

- θ 600R, 600QS, 600XL, 600XLM, 600 OMS V2-1, 600LS, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 Sondes with Calibration Cup and Probe Guard
- θ EcoWatch for Windows Software
- θ Operations Manual
- θ Guard for Probe Compartment
- θ 6570 Maintenance Kit (all sondes except 600R and 600QS)
- θ 6583 Maintenance Kit (600R and 600QS)
- θ 6560 Conductivity/Temperature Probe (not supplied with the 600R, 600QS, 600LS, or 600 OMSV2-1 because of integral conductivity sensors)

PROBES FOR THE SONDES

(See Appendix M, Sonde Specifications for the probes that your sonde supports)

- θ 6560 Conductivity/Temperature Probe
- θ 6561 pH Probe
- θ 6561FG Flat Glass pH Probe
- θ 6562 Rapid Pulse DO Probe
- θ 6150 ROX Optical DO Probe
- θ 6565 Combination pH/ORP Probe
- θ 6565FG Flat Glass Combination pH/ORP Probe
- θ 6566 Combination pH/ORP Probe, Fouling Resistant
- θ 6025 Chlorophyll Probe, wiped
- θ 6130 Rhodamine WT Probe, wiped
- θ 6131 Phycocyanin Probe, wiped
- θ 6132 Phycoerythrin Probe, wiped
- θ 6136 Turbidity Probe, wiped
- θ 6882 Chloride Probe
- θ 6883 Ammonium Probe
- θ 6884 Nitrate Probe
- θ 6580 Reference Electrode Replacement for 600R Sonde

OPTIONAL ACCESSORIES FOR THE SONDES

- θ 062781 PC6000 Software (Available at no cost)
- θ 655423 Spare Probe Installation Tool
- θ 6155 Replacement Membrane Kit for ROX Optical DO Probe
- θ 6627 Turbidity Wiper Kit, White
- θ 6624 Chlorophyll and Rhodamine WT Fluorescent Wiper Kit for 6025 and 6130, Orange
- θ 6625 ROX Optical DO and BGA Wiper Kit for 6150, 6131, and 6132, Black
- θ 6144 Optical Wiper Pad Kit for 6027, 6627, 6024, and 6624 Wiper Assemblies

- 6628 Wiper Kit for 6600EDS V2-2 Sonde, White
- 6630 Wiper Kit for 6600EDS V2-2 Sonde, Black
- 6035 Probe Reconditioning Kit for 6562 Dissolved Oxygen Probe
- 6038 12 VDC Power Supply with 110 VAC input
- 6651 12 VDC Power Supply with 90 to 264 VAC input
- 6100 External Power Connector, attaches to 6095B Field Cable
- 6101 Power Pack, 12 VDC, MS-4
- 6570 Maintenance Kit
- 5775 Membrane Kit
- 690 Replacement Sonde Weight for 600 series sondes, Small
- 691 Replacement Sonde Weight for 600 series sondes, Large
- 6885 Sonde Weight Kit for 6820 and 6920 series sondes
- 6044 Sonde Weight for 6600 series sondes
- 6182 Zinc Anode Kit
- 6108 Desiccant Cartridge Kit
- 6109 Desiccant Canister Kit
- 065802 Replacement Desiccant
- 6120 6-Series Operations Manual, Spanish
- 6121 6-Series Operations Manual, German
- 116275 Extended Length Calibration Cup Assembly for 6600V2-2, 6600EDS V2-2, and 6600V2-4 Sondes
- 655488 Extended Length Calibration Cup Sleeve for 6820V2-1, 6820V2-2, 6920V2-1, and 6920V2-2 Sondes
- 066267 Decreased Length Calibration Cup Sleeve for 6600V2-4 Sonde

FLOW CELLS FOR THE SONDES

- 6601 Flow Cell for 6600V2-2 Sonde
- 131041460 (Endeco Part #) Flow Cell for 6600EDS V2-2 and 6600V2-4 Sondes
- 5083 Flow Cell for 600XL and 600XLM
- 6160 Flow Cell for 6820V2-1, 6820V2-2 , 6920V2-1, and 6920V2-2 Sondes
- 696 Flow Cell for 600R

CABLES FOR THE SONDES

- 6093 Field Cable, 100 ft (30 m)
- 6092 Field Cable, 50 ft (15 m)
- 6091 Field Cable, 25 ft (7.5 m)
- 6090 Field Cable, 8 ft (2.4 m)
- 6191 Field Cable, Vented, 25 ft (7.5 m)
- 6192 Field Cable, Vented, 50 ft (15 m)
- 6067 Low Cost Calibration Cable, Dry use only; 10 ft (3m)
- 6077 CE Calibration Cable, 10 ft. (3m)
- SP6093-L Special field cables available in 25 ft(7.6 m) increments; Maximum 1000 ft (305m)
- 6096 MS-8 to Flying Lead (wire) adapter, 15 ft (5m)
- 6095 Field Cable to Female DB-9 (PC Serial with Power Connector)
- 6103 MS-8 Dust Cover (caps connector when not in use)

CONDUCTIVITY REAGENTS

- θ 3161 Calibrator Solution, 1,000 uS/cm (quart)
- θ 3163 Calibrator Solution, 10,000 uS/cm (quart)
- θ 3165 Calibrator Solution, 100,000 uS/cm (quart)
- θ 3167 Calibrator Solution, 1,000 uS/cm (box of 8 pints)
- θ 3168 Calibrator Solution, 10,000 uS/cm (box of 8 pints)
- θ 3169 Calibrator Solution, 50,000 uS/cm (box of 8 pints)

pH REAGENTS

- θ 3821 pH 4 Buffer (box of 6 pints)
- θ 3822 pH 7 Buffer (box of 6 pints)
- θ 3823 pH 10 Buffer (box of 6 pints)
- θ 3824 Assorted Buffers (2 bottles of pH 4, pH7, and pH 10 Buffers)

ORP REAGENTS

- θ 3682 Zobell Solution (125 ml)

AMMONIUM REAGENTS

- θ 3841 1 mg/L ammonium-nitrogen standard solution
- θ 3842 10 mg/L ammonium-nitrogen standard solution
- θ 3843 100 mg/L ammonium-nitrogen standard solution

NITRATE REAGENTS

- θ 3885 1 mg/L nitrate-nitrogen standard solution
- θ 3886 10 mg/L nitrate-nitrogen standard solution
- θ 3887 100 mg/L nitrate-nitrogen standard solution

TURBIDITY REAGENTS

- θ 6073 126 NTU standard suspension, 1 pint
- θ 6073G 126 NTU standard suspension, 1 gallon
- θ 6072 12.7 NTU standard suspension, 1 gallon
- θ 6074 1000 NTU standard suspension, 1 gallon
- θ 6080 0 NTU turbidity-free water, 1 gallon

DISPLAYS, LOGGERS, AND ACCESSORIES

- θ 650-01 – Low memory with no barometer
- θ 650-02 – High memory with no barometer
- θ 650-03 – Low memory with barometer

- θ 650-04 – High memory with barometer
- θ 6112 PC Interface Cable. PC to 650 MDS.
- θ 6113 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6114 110 volt wall charger, and 6117 battery pack included
- θ 6126 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, European power cable, British power cable, and 6117 battery pack included
- θ 6127 Rechargeable Battery Pack Kit with 6116 charger adapter cable, 6123 universal charger, China/Australia power cord, and 6117 battery pack included
- θ 4654 Tripod
- θ 614 Ultra Clamp
- θ 5085 Hands Free Harness
- θ 5065 Form-fitting Case
- θ 6930 Hard-sided Case
- θ 6655 Soft-sided Case
- θ 6124 Backpack
- θ 6117 Extra Rechargeable Battery Pack for 650 MDS
- θ 6115 GPS Cable for interface with user-supplied GPS unit
- θ 616 Cigarette Lighter Charger

LOGGER/TELEMETRY

- θ 6200 Data Acquisition System (6200 DAS) and Accessories. Contact YSI Massachusetts (1-800-363-3269) for options and ordering information.

SOFTWARE

- θ 6075 EcoWatch for Windows for use with 6-series applications; also available at no cost from the ysi.com website.
- θ Software upgrades for sondes and 650 – See ysi.com website

ANTI-FOULING

- θ 6145-AF Sonde Guard Kit, 6600
- θ 6151-AF Port Plug Kit, Large
- θ 6161-AF Port Plug Kit, Small
- θ 6171-AF Port Plug Kit, ISE
- θ 6176-AF Sonde Guard Kit, 6820/6920
- θ 6189-AF Copper Tape Kit
- θ 6445-AF Wiper Brush Kit, 6600V2
- θ 6625-AF Wiper Kit, Optical
- θ 6630-AF Wiper Brush Kit, EDS

APPENDIX D SOLUBILITY AND PRESSURE/ALTITUDE TABLES

Table 1: Solubility of Oxygen (mg/L) in Water Exposed to Water-Saturated Air at 760 mm Hg Pressure.

Salinity = Measure of quantity of dissolved salts in water.
Chlorinity = Measure of chloride content, by mass, of water.
$S(^0/_{00}) = 1.80655 \times \text{Chlorinity } (^0/_{00})$

Temp °C	Chlorinity 0 Salinity: 0	5.0 ppt 9.0 ppt	10.0 ppt 18.1 ppt	15.0 ppt 27.1 ppt	20.0 ppt 36.1 ppt	25.0 ppt 45.2 ppt
0.0	14.62	13.73	12.89	12.10	11.36	10.66
1.0	14.22	13.36	12.55	11.78	11.07	10.39
2.0	13.83	13.00	12.22	11.48	10.79	10.14
3.0	13.46	12.66	11.91	11.20	10.53	9.90
4.0	13.11	12.34	11.61	10.92	10.27	9.66
5.0	12.77	12.02	11.32	10.66	10.03	9.44
6.0	12.45	11.73	11.05	10.40	9.80	9.23
7.0	12.14	11.44	10.78	10.16	9.58	9.02
8.0	11.84	11.17	10.53	9.93	9.36	8.83
9.0	11.56	10.91	10.29	9.71	9.16	8.64
10.0	11.29	10.66	10.06	9.49	8.96	8.45
11.0	11.03	10.42	9.84	9.29	8.77	8.28
12.0	10.78	10.18	9.62	9.09	8.59	8.11
13.0	10.54	9.96	9.42	8.90	8.41	7.95
14.0	10.31	9.75	9.22	8.72	8.24	7.79
15.0	10.08	9.54	9.03	8.54	8.08	7.64
16.0	9.87	9.34	8.84	8.37	7.92	7.50
17.0	9.67	9.15	8.67	8.21	7.77	7.36
18.0	9.47	8.97	8.50	8.05	7.62	7.22
τ						τ

τ						τ
19.0	9.28	8.79	8.33	7.90	7.48	7.09
20.0	9.09	8.62	8.17	7.75	7.35	6.96
21.0	8.92	8.46	8.02	7.61	7.21	6.84
22.0	8.74	8.30	7.87	7.47	7.09	6.72
23.0	8.58	8.14	7.73	7.34	6.96	6.61
24.0	8.42	7.99	7.59	7.21	6.84	6.50
25.0	8.26	7.85	7.46	7.08	6.72	6.39
26.0	8.11	7.71	7.33	6.96	6.62	6.28
27.0	7.97	7.58	7.20	6.85	6.51	6.18
28.0	7.83	7.44	7.08	6.73	6.40	6.09
29.0	7.69	7.32	6.96	6.62	6.30	5.99
30.0	7.56	7.19	6.85	6.51	6.20	5.90
31.0	7.43	7.07	6.73	6.41	6.10	5.81
32.0	7.31	6.96	6.62	6.31	6.01	5.72
33.0	7.18	6.84	6.52	6.21	5.91	5.63
34.0	7.07	6.73	6.42	6.11	5.82	5.55
35.0	6.95	6.62	6.31	6.02	5.73	5.46
36.0	6.84	3.52	6.22	5.93	5.65	5.38
37.0	6.73	6.42	6.12	5.84	5.56	5.31
38.0	6.62	6.32	6.03	5.75	5.48	5.23
39.0	6.52	6.22	5.98	5.66	5.40	5.15
40.0	6.41	6.12	5.84	5.58	5.32	5.08
41.0	6.31	6.03	5.75	5.49	5.24	5.01
42.0	6.21	5.93	5.67	5.41	5.17	4.93
43.0	6.12	5.84	5.58	5.33	5.09	4.86
44.0	6.02	5.75	5.50	5.25	5.02	4.79
45.0	5.93	5.67	5.41	5.17	4.94	4.72

Table 2: Calibration Values for Various Atmospheric Pressures and Altitudes

PRESSURE			ALTITUDE		CALIBRATION VALUE
Inches Hg	**mm Hg**	**Millibars**	**Feet**	**Meters**	**Percent Saturation**
30.23	768	1023	-276	-84	101
29.92	760	1013	0	0	100
29.61	752	1003	278	85	99
29.33	745	993	558	170	98
29.02	737	983	841	256	97
28.74	730	973	1126	343	96
28.43	722	963	1413	431	95
28.11	714	952	1703	519	94
27.83	707	942	1995	608	93
27.52	699	932	2290	698	92
27.24	692	922	2587	789	91
26.93	684	912	2887	880	90
26.61	676	902	3190	972	89
26.34	669	892	3496	1066	88
26.02	661	882	3804	1160	87
25.75	654	871	4115	1254	86
25.43	646	861	4430	1350	85
25.12	638	851	4747	1447	84
24.84	631	841	5067	1544	83
24.53	623	831	5391	1643	82
24.25	616	821	5717	1743	81
23.94	608	811	6047	1843	80
23.62	600	800	6381	1945	79
23.35	593	790	6717	2047	78
23.03	585	780	7058	2151	77
22.76	578	770	7401	2256	76
22.44	570	760	7749	2362	75
22.13	562	750	8100	2469	74
21.85	555	740	8455	2577	73
21.54	547	730	8815	2687	72
21.26	540	719	9178	2797	71
20.94	532	709	9545	2909	70
20.63	524	699	9917	3023	69
20.35	517	689	10293	3137	68
20.04	509	679	10673	3253	67
19.76	502	669	11058	3371	66

Table 3. Conversion Factors for Feet/Meters, Celsius/Fahrenheit, mg/L/ppm

TO CONVERT FROM	TO	EQUATION
Feet	Meters	Multiply by 0.305
Meters	Feet	Multiply by 3.28
Degrees Celsius	Degrees Fahrenheit	$5/9\times(^{o}F-32)$
Degrees Fahrenheit	Degrees Celsius	$9/5\times(^{o}C)+32$
Milligrams per liter (mg/L)	Parts per million (ppm)	Multiply by 1

Table 4. Conversion Factors for Common Units of Pressure

	kilo Pascals	mm Hg	millibars	inches H_20	PSI	inches Hg
1 atm	101.325	760.000	1013.25	406.795	14.6960	29.921
1 kiloPascal	1.00000	7.50062	10.0000	4.01475	0.145038	0.2953
1 mmHg	0.133322	1.00000	1.33322	0.535257	0.0193368	0.03937
1 millibar	0.100000	0.750062	1.00000	0.401475	0.0145038	0.02953
1 inch H_20	0.249081	1.86826	2.49081	1.00000	.0361	0.07355
1 PSI	6.89473	51.7148	68.9473	27.6807	1.00000	2.0360
1 inch Hg	3.38642	25.4002	33.8642	13.5956	0.49116	1.00000
1 hectoPascal	0.100000	0.75006	1.00000	0.401475	0.0145038	0.02953
1 cm H_20	0.09806	0.7355	9.8×10^{-7}	0.3937	0.014223	0.02896

APPENDIX E TURBIDITY MEASUREMENTS

This appendix is in the format of "frequently asked questions, is designed to allow users to optimize the performance and trouble-shooting problems for your YSI 6136 turbidity probe by supplementing the discussion of turbidity that is provided in the other sections of this manual (Getting Started, Basic Operation, Principles of Operation, and Maintenance).

Where should I get my turbidity standards?

To properly calibrate YSI turbidity sensors, you MUST use standards that have been prepared according to details in *Standard Methods for the Treatment of Water and Wastewater (Section 2130 B)*. Acceptable standards include (a) formazin prepared according to *Standard Methods*; (b) dilutions of 4000 NTU formazin concentrate purchased from Hach; (c) Hach StabCal™ standards in various NTU denominations; and (d) AMCO-AEPA standards prepared specifically for the 6136 by either YSI or an approved YSI vendor as listed on YSI website (www.ysi.com). STANDARDS FROM OTHER VENDORS OTHER THAN HACH, YSI, OR YSI-APPROVED ARE NOT ACCEPTABLE FOR USE WITH THE YSI TURBIDITY SYSTEM AND THEIR USE WILL LIKELY RESULT IN BOTH CALIBRATION ERRORS AND INCORRECT FIELD READINGS.

For the best combination of accuracy and ease of use, we recommend that you use standards that have been prepared from AMCO-AEPA polymer beads by either YSI or a YSI-approved vendor. This material is listed as a secondary turbidity standard by *Standard Methods for the Examination of Water and Wastewater.* These standards have been certified to be the proper value in NTUs by comparison of their turbidity outputs with those of freshly prepared formazin, the latter being the most accepted primary standard for turbidity. The polymer standards can be linearly diluted with turbidity free water to generate standards that are lower in value and which can then also be used as calibrants. For example, diluting 50 mL of 100 NTU standard to a total volume of 500 mL will yield a 10 NTU standard.

You can also use formazin as your source for turbidity standards. The formazin can be generated by the procedure found in *Standard Methods for the Examination of Water and Wastewater,* or it can be purchased from Hach as a 4000 NTU suspension that can be linearly diluted to form lower NTU standards. In addition, Hach offers formazin turbidity standards in a variety of NTU values under the StablCal™ designation and these standards may prove useful for the calibration of your YSI turbidity sensor. The advantage of the use of formazin is its cost; the primary disadvantage is that it is a somewhat hazardous reagent for which care must be taken in handling and disposal. In addition, formazin settles out much more rapidly than the AMCO-AEPA polymer and may be less stable to degradation in dilute form. If you use formazin, we recommend that you purchase from Hach either the 4000 NTU concentrate and dilute it or the StablCal™ standards in the proper turbidity concentrations for your application, rather than generating the reagent from the chemical reaction described in *Standard Methods for the Examination of Water and Wastewater*. Whatever your source of formazin, be very safety conscious if you use it and be sure to follow the manufacturer's instructions with regard to its handling and disposal.

Remember that is imperative that you do **NOT** use standards that are based on suspended materials other than formazin or AMCO-AEPA polymer or have been prepared by vendors other than YSI, YSI-approved suppliers, or Hach. These standards will **NOT** read correctly when measured with the YSI turbidity systems. If you have any doubts about the composition of your standards, consult your supplier and be certain that they are based on either formazin or AMCO-AEPA materials and were prepared by the proper method.

Do I have to buy turbidity-free water for the 0 NTU calibration?

For most applications, purified water of any kind (distilled, deionized or filtered) will be acceptable for the 0 NTU standard. This water can be obtained from a laboratory or can be purchased at a local supermarket. It is

not recommend that you use tap water as the 0 NTU standard. For maximum accuracy at very low NTU values (below the specification of the instrument), you may want to purchase turbidity-free water from YSI or another vendor.

Should I carry out a 1-point, 2-point, or 3-point turbidity calibration, and what values should I use?

Even though the default calibration value in your sonde is reasonably appropriate for the "average" 6136 sensor, you need to carry out some multi-point calibration (2- or 3-point) prior to your first usage. This will make certain that your system meets the YSI accuracy specifications provided in the operations manual. For the accuracy required in most environmental applications, a 2-point calibration is sufficient, and it is recommended that the two points be 0 and approximately 100 NTU – YSI offers a 126 NTU standard. Only if you desire extreme accuracy in, for example, the 100-1000 NTU range, should you carry out a 3-point calibration at 0, ca. 100, and ca. 1000 NTU. Note, however, that the effect on accuracy may be too small to overcome the inconvenience of using the 3-point routine and the cost of the 1000 NTU standard.

Once the initial multi-point calibration of the 6136 sensor has been carried out, we recommend that the accuracy of the sensor at low NTU be checked (or reset) by performing a **1-point** calibration at 0 NTU before each usage.

How often should I perform additional multi-point calibrations?

Your frequency of calibration will depend on the conditions under which your sonde is used and on the degree of accuracy required in your application. Periodic calibration also confirms that the sensor is performing properly with regard to its sensitivity and general function.

Our empirical testing has indicated that the optical system of the 6136 probe is very stable and likely to require only infrequent calibration. However, you should initially confirm the stability of the sensor for your typical sampling or monitoring application by frequently checking the sensor reading in a standard other than 0 NTU prior to increasing the time between multi-point calibrations.

What color wiper should be used with my 6136 turbidity sensor?

The optimal wiper color for the 6136 depends on the software which is installed in the sonde. For versions of 6-series software prior to 3.00, a white wiper should be used. For versions of software after 3.00, a black wiper should be used. The difference exists due to an improvement in the wiper parking algorithm which was implemented with Version 3.00 of software. If your sonde software version is pre-3.00, YSI strongly recommends that you upgrade the software via the YSI Website and then use black wipers.

How do I purchase new wipers for the 6136 turbidity sensor?

Entire wiper assemblies, complete with installed pad, can be purchased from YSI in the 6627 Wiper Replacement Kit (White) or the 6625 Wiper Kit (Black). If you wish to just change the pad on your old wiper assemblies, you can purchase the 6144 Wiper Pad Kit from YSI.

What about data filter and spike rejection settings for processing turbidity data from the YSI turbidity system?

As described in **Section 5, Principles of Operation**, some processing of raw turbidity data is usually beneficial in terms of outputting values that reflect the "average" turbidity at the site. Filter options designed to optimize this data processing are located in the sonde menu structure under both the **3-Sensor** and the **4-Data Filter** selections in the **6-Advanced** submenu.

For most applications involving both spot sampling and monitoring, the following settings are recommended with regard to data processing:

- In **3-Sensor**, activate the "Turb Spike Filter"
- In **4-Data Filter**, "Enable" the filter.
- In **4-Data Filter**, "Disable" the "Wait for Filter" selection.
- In **4-Data Filter** for turbidity, set the Time Constant to 12
- In **4-Data Filter** for turbidity, set the Threshold to 0.010

These settings will normally produce data that is reflective of the "average" turbidity without having any significant effect on the response times of the other sensors. Increasing the values of the time constant, threshold, or both can further smooth the turbidity values, but also are likely to increase the apparent response time of the sensor.

How do I set up 6-series sondes for logging turbidity data to internal memory?

First, as outlined above, set the data filter and turbidity spike filter settings as recommended in the previous question/answer. Second, access **2-Setup** in the **Advanced** submenu and make certain that the "Turb Wipes" entry is set to "1". Finally, in the same submenu, set the "Twipe Int" parameter (in minutes) to the same value as the sample interval for which data will be transmitted to the logging device. For example, if **Sample Interval** is set to" 900 seconds" (15 minutes) in the Discrete Sample Run menu or "15 minutes" in the Unattended mode, set "Twipe Int" to "15". Under these conditions, the turbidity wiper will be activated in a single bi-directional cleaning motion every 15 minutes to clean bubbles and fouling from the optics of the probe and minimize the chance of corrupted readings due to these factors. Note, however, that for Unattended applications with the sonde where data is being logged to internal sonde memory and "Autosleep RS232" is activated, it is only necessary that the value of Twipe Int be less than that of the sample interval selected for the Unattended study. Thus, if Twipe Int is set to 5 minutes and the Unattended sample interval is set to 15 minutes, the sensor will only be cleaned every 15 minutes. For this reason, if you use your sonde primarily for Unattended monitoring, it is recommended that you leave Twipe Int at the default setting of "5", even though this is different from your sample interval. As outlined in the manual, in sites where fouling is more prevalent, it may be necessary to set "Turb Wipes" to a higher value, but a setting of "1" will be adequate for most water.

After sonde software setup is complete as outlined above, attach the sonde to a computer or a 650 MDS and calibrate all sensors (including turbidity). Then set up an Unattended study at your desired sample interval and deploy the sonde without cable connections for later data upload and analysis.

How do I set up 6-series sondes with turbidity for use with a Data Collection Platform (DCP?

If your 6-series sonde with a turbidity sensor will be attached to a data collection platform, you should calibrate the sensors (including turbidity) prior to DCP connection. You should also make sure that the "SDI12/M" factor which is found in the Advanced|Sensor menu is set to a value of "1" to ensure proper wiping of the turbidity probe during deployment on the DCP. Then connect the sonde to the data collection platform using the proper cable/adapter and begin sampling according to the instruction manual.

How do I manually activate the turbidity wiper on a 6136 turbidity probe when the sonde is sampling?

If you are using the sonde with a 650, highlight the "Clean Optics" entry in the upper right logging box and press **Enter** to activate the wiper. If the sonde is connected to a computer (sequential lines of data are present on the screen), press the "3" key to activate the wiper.

What precautions should I take when using the sonde turbidity system with a 650 MDS display/logger in sampling applications where the user is present?

Prior to observing or logging turbidity readings, you should always activate the wiper manually for the 650 keypad to remove bubbles/and or fouling.

What are the things most likely to give me problems when measuring turbidity with the 6136 probe and YSI 6-series sondes?

The turbidity system has been designed to be easy to calibrate, easy to use in both sampling and deployment applications, and trouble-free in normal usage. However, during our empirical testing, we have observed occasional problems in calibration and in field applications. These difficulties are likely to be experienced only infrequently by users. In fact, most of these problems are not due to any malfunction in the turbidity system itself, but instead occur because of contaminated calibration solutions or the presence of bubbles on the optics of the probe. However, we have gained experience in separating problems which can be easily solved by the user from those which involve sensor malfunction and must be dealt with by YSI Technical Support and Product Repair. This section is intended to pass this experience along to the user.

You might see calibration errors. This problem could be due to bubbles on the optical surface, contamination of your 0 NTU standard, or a higher calibration standard which has not been prepared properly or has been contaminated or diluted inadvertently. The problem could also be due to an internal malfunction of the probe optical system. To troubleshoot the problem, do **not** override the cal error, return to the Main menu and activate Discrete Sampling in the Run mode. Remove the sonde guard and place your thumb or finger over the optics of the probe while observing the data display. A high (>1000 NTU) reading should be observed if the probe is responding correctly from an optical standpoint. If no response is noted, the probe must be returned to YSI Product Service for repair or replacement. CAUTION: DO NOT ATTEMPT TO DISASSEMBLE THE PROBE YOURSELF. If the probe is functioning properly, replace the probe guard and place the sonde back into 0 NTU water. Activate the wiper manually and enter the calibration routine of choice (1-, 2-, or 3-point) from the **Calibrate** menu. Observe the readings for the 0 NTU standard. If values higher than about 5 NTU are observed, it is possible that your 0 NTU standard has been contaminated from debris that was retained on the sonde and probes from the previous field usage. Discard the water, rinse the sonde, and replace in new 0 NTU standard. After agitation, check the reading to see if it has been reduced. If so, proceed with the second calibration point. If not, contact YSI Technical Support for further assistance. If a calibration error occurs on the second point, use a new source of standard and try again. If an error still occurs, contact YSI Technical Support for further assistance.

You might observe slightly negative readings in very clear water. This effect is usually due to one of two causes:

1. The "zero" turbidity standard which you have used is not really 0 NTU because of inadvertent contamination. This contamination usually occurs when the fouling from a sonde just taken from the field contaminates the turbidity-free water used for the zero point. To overcome the problem, be sure to clean the sonde as well as possible prior to recalibration of the turbidity sensor and then assure that the zero reading is as low as possible by changing the turbidity-free water until no further lowering of the reading is noted.

2. The probe is experiencing "interference" from the calibration cup bottom during the zero point calibration. This "interference" can due to (a) improperly using a calibration cup with a gray (rather than black) bottom; (b) using a calibration cup with a black bottom which has been contaminated with impurities; or (c) having the probe too close to a the calibration cup bottom. To overcome (a), be sure to use install the black bottom that came with your 6136 into your calibration cup. To overcome (b) be sure that the black bottom of the calibration cup is clean before performing a calibration. To overcome (c), make certain that you engage only ONE THREAD when screwing the calibration cup onto the sonde in order to keep the turbidity probe face as far as possible from the calibration cup bottom to avoid interference. To completely overcome the "interference" problem, use the extended length calibration cup (#116275 for 6600-style sondes and #069310 for 6820/6920-style sondes). Note, however, the longer calibration cups will require larger volumes of calibration standard.

You might observe readings during sampling which appear unreasonable from visual inspection of the water. Bubbles on the optics of the sensor usually cause the problem. Activate the wiper to remove the bubbles. If the readings are still unreasonable, remove the sonde completely from the water and then replace in the water. If problems are still evident, remove the sonde guard and check general probe function by placing your finger or thumb over the optics as described above. If the probe does not respond, contact YSI Technical Support.

You might see readings during sampling that you think are too jumpy. If this occurs, the water may be non-homogeneous with regard to the size of the suspended particles. The jumpiness that you are observing is probably real. However, if you want to smooth it out, you can incrementally increase the Time Constant and Threshold settings in the Data Filter menu to obtain the noise level which you desire.

You might observe single point spikes in data from deployment applications. These high readings may be real turbidity events caused by large particles passing over the optical surface at the time of measurement. As long as the spiking occurs only occasionally, there is no reason to believe that the turbidity system is malfunctioning. Depending on the site, these spikes may be a normal occurrence.

You might see a lot of unreasonable high spikes in data from deployment applications. This symptom usually results from improper activation or parking of the wiper assembly. If it occurs with a new wiper assembly, make certain that the wiper rotates and parks correctly (opposite the optical surface) in 0 NTU standard. If the wiper does not rotate at all, be certain that the setscrew of the assembly is contacting the flat part of the shaft and that the screw is securely tightened using the small hex key that is supplied with the wiper assembly. If the wiper still will not rotate on manual activation, contact YSI Technical Support. If the problem occurs with a wiper assembly which has been in the field for some time and is discolored or abraded, install a replacement wiper with a new pad, assure function and correct parking in 0 NTU standard, and redeploy. If a high frequency of spikes still occurs in the deployment data, contact YSI Technical Support for further assistance.

APPENDIX F FLOW

Flow is only available in the **Sensors** menu on sondes that have vented level. The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu.

Note: In this manual we describe how to use YSI's sondes to calculate flow from vented level. While weirs, flumes and the Manning equation are described briefly here, this manual is not a complete treatment of the subject. We make no claims on the accuracy or appropriateness of any of these techniques for any particular application.

Flow is a calculated value. Whenever there is a one to one relationship between the level of water in an open channel and the flow of water through it, then flow can be calculated from a level measurement. Many devices are designed to be placed in an open channel to improve the determination of flow. For example, a weir is a dam of specific geometry that restricts the flow of water while giving a very repeatable and accurate relationship between level and flow. There are several varieties of weirs, each designed for a specific application. Similarly, a flume also restricts flow producing a repeatable and accurate flow/level curve by forcing the flow not over a dam, but through a narrower portion of the channel. The flow is gradually narrowed, passed through a throat in the flume, and then gradually expanded back to the original channel width. As with weirs, there are several varieties of flumes each designed for a specific application.

The weir or flume is referred to as the primary measuring device, and the level meter is referred to as the secondary measurement device. There are three common types of weirs and seven types of flumes. Most of these are available in a number of sizes. Flow/level curves for common types and sizes are already programmed in the sonde so that it is only necessary to describe the primary measuring device to get flow readings. If you have a primary measuring device that is not already programmed, you have the option of entering either an equation or a table that defines the flow/level curve for your device. The table can also be used to calculate the flow of water in stream for which the flow/level data is available.

The Manning Equation is also available to calculate flow in an open channel without any restriction built explicitly for measuring flow. In this case the channel itself is the primary measuring device.

SETTING UP YOUR SONDE

WEIR OR FLUME

Getting your sonde ready to calculate flow for a weir or a flume can be summarized in the following simple steps. Using EcoWatch or a 650 MDS display/logger to communicate with the sonde:

1. Enable **Flow** in the **Sensors** menu.
2. Go to **Flow Setup** menu in the **Advanced**|**Sensor** menu**.**
3. Choose a method (flume or weir), then a type (V-notch, rectangular, Parshall, etc.).
4. Choose a size.
5. Verify proper setup, choosing preferred units.
6. Choose preferred units in the **Report** menu.

The **Flow Setup** menu only appears when **Flow** is enabled in the **Sensors** menu. Once in the **Flow Setup** menu you must define your primary measuring device by **Method, Type**, and **Size**. Note that the menus change depending upon your selection.

For example, after choosing **Flume** for your method, only types of flume are shown. So it is important to choose first the method, then the type, and finally the size. The following chart lists the primary devices that are programmed in the sonde.

Method	Type	Size
Weir	V-Notch	22½°, 30°, 45°, 60°, 90°, 120°
	Rectangular w/ End Contractions	Any size
	Rectangular w/o End Contractions	Any size
	Cipolletti	Any size
Flume	Parshall	1”, 2”, 3”, 6”, 9” 12”, 18”, 2’, 3’, 4’, 5’, 6’, 8’, 10’, 12’
	Palmer-Bowlus	4”, 6”, 8”, 10”, 12”, 15”, 18”, 21”, 24”, 27”, 30”
	Leopold-Lagco	4”, 6”, 8”, 10”, 12”, 15”, 18”, 21”, 24”, 30”
	Trapezoidal	Large 60° V, X-large 60° V, 2” 45° WSC, 12” 45° SRCRC
	Hs	0.4ft, 0.6ft, 0.8ft, 1ft,
	H	0.5ft, 0.75ft, 1 ft, 1.5ft, 2ft, 2.5ft, 3 ft, 4.5 ft
	HL	4 ft

After selecting the method, type and size of primary device, YSI strongly recommends that you verify that the sonde is set up properly. Find a chart that lists head versus flow for your primary measuring device. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that are on your chart. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against those found in the chart. Note that there may be minor differences in the least significant digit between the published values and the values given by the sonde. The difference is generally much less than the overall tolerance of the weir or flume being used.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

MANNING EQUATION

Once in the **Flow Setup** menu, choose **Manning** for the Method and then choose which type of channel the measurement is to be done in: closed pipe, U- channel, rectangular, or trapezoidal. Then choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. Finally choose **Setup Manning** and define the width of the channel, its roughness and slope. Roughness is given in many fluid hydraulics texts and other engineering references as the Manning coefficient, n. Empirical values for n are given in the same references for most commonly found materials used in open channel construction. Slope is the ratio of rise to run. For example, if a channel drops one foot every one hundred feet, the value of the slope would be 0.01.

After setting up the **Manning Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and judge whether the resulting **Test Flow** values are reasonable. You might even want to try doing the calculation yourself.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

EQUATION

Equation is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde. (**Table** is also sometimes useful for this purpose.)

Once in the **Flow Setup** menu you must define the equation. First choose the units for the equation. It is very important that the units chosen match the coefficients for the equation. The equation is of the form:

$$Q = K_1 \bullet H^{P_1} + K_2 \bullet H^{P_2}$$

Enter values for **K1, P1, K2,** and **P2.** Note: if you do not need the second term in the equation, simply enter zero for **K2**.

After setting up the **Equation**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units that you prefer. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values that you have calculated.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

TABLE

Table is used to calculate flow with primary measuring devices other than the ones already programmed in the sonde (**Equation** is also sometimes useful for this purpose). **Table** can also be used to calculate flow in streams for which there is data relating flow to level.

Once in the **Flow Setup** menu you must define your **Table**. Do this by entering up to 50 pairs of **Head** and **Flow** data points. Choose **Setup Table**. Be sure to choose the units that match the data in your table. Then enter each pair of points one by one. It is not necessary to enter the points in order. The software will put them in order. There are items on the menu to edit the next point or the previous point, to enter a new point, to delete a point or to delete the entire table. Later, when the sonde is measuring level and calculating flow, it will linearly interpolate between points in the table.

After setting up the **Table**, we strongly recommend that you verify that the sonde is set up properly. From the **Flow Setup** menu choose **Test Flow**. Then choose the units and flow units used in the table. Enter a few values for **Test Head** and compare the resulting **Test Flow** values against values in the original table.

The final step is to return to the **Report** menu and choose the flow and volume units you wish to have in the report. Note that the units in the report menu are independent of the units in the **Flow Setup** menu.

DEPLOYING YOUR SONDE

WEIR

Deployment of the sonde in a weir is normally very simple. Generally the point of level measurement is recommended to be at a distance upstream of the weir equal to 3 to 4 times the maximum level expected; however, do not deploy the sonde without knowing the design measurement point for the weir you are using. If flow is overly turbulent and readings are jumpy, then it may be necessary to install a stilling well for the sonde. If other water quality measurements are of interest (DO, pH, etc,) then take care that the stilling well does not overly isolate the sonde from the water in the channel.

Deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a weir. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure also to follow the instructions printed in Appendix G, **Using Vented Level**.

FLUME

Generally there is a staff gauge installed in a flume at the point where the level should be measured. Be certain that you know the location of the measurement for the flume you are using. Some flumes are built with a stilling well outside of the flume. Deploying the sonde in the stilling well will give accurate level readings, but readings of other parameters like DO and pH may not be equivalent to those in the main flow of the flume. Also be aware that many flumes are not much bigger than the sonde. Installing the sonde in the flume may change the way the flume behaves, thus causing errors in flow readings. An ideal deployment would include a flume with a recess for the sonde that locates the pressure sensor properly, allows the other sensors to measure the water flowing through the flume, and does not significantly alter the geometry of the flume. In a flume this means deploying the sonde horizontally. If possible, deploy the sonde so that the pressure sensor on the side of the sonde is slightly below the lowest level expected. Also be aware that the pressure sensor in the sonde is along the side of the sonde and not at its very tip. If a sonde is deployed vertically in the flume, then it may not be able to make measurements when the water level is low. Be sure the sonde is installed so that it cannot move during measurement.

Normally, a staff gauge is installed with a flume. After the sonde is installed, calibrate depth to the value read off the staff gauge.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

USING THE MANNING EQUATION IN AN OPEN CHANNEL

The channel should be large enough that the sonde does not significantly alter the flow of water. Most deployments will require the sonde to be in the channel horizontally so that the pressure sensor remains submerged at all times. Be sure that the sonde cannot move during the measurement. After installation measure the depth of water in the channel with a ruler and use that measurement to calibrate depth on the sonde.

Be sure to follow the instructions printed in Appendix G, **Using Vented Level**.

APPENDIX G USING VENTED LEVEL

Sondes that are equipped with level sensors use vented cables. The vented level option eliminates errors due to changes in barometric pressure. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs up through the sonde and cable. The tube must remain open and vented to the outside atmosphere to function. All storage caps must be removed and no foreign matter can block the openings. Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant system in place. This prevents moisture from entering the vent tube.

Special field cables are used for the vented level. These cables have a vent tube that runs up the middle of the cable. Your sonde has a stainless steel connector on the top of it. In the center of this connector is the vent hole. When the cable is removed from the sonde, seal the sonde with the pressure cap provided with the sonde, to keep it clean and dry. The field cable should also be stored in a sealed plastic bag with some desiccant to keep it dry.

At the instrument end of every vented cable is a barbed fitting. This is to provide an attachment for a desiccant system. One of the two desiccant systems should always be attached to the sonde while exposed to the atmosphere to prevent moisture buildup in the vent tube. When dry and active, the desiccant is a distinct blue color. When exhausted it turns to a rose red or pink color. The desiccant can be regenerated in an oven. See **Section 2.10, Care, Maintenance and Storage** for the proper procedure.

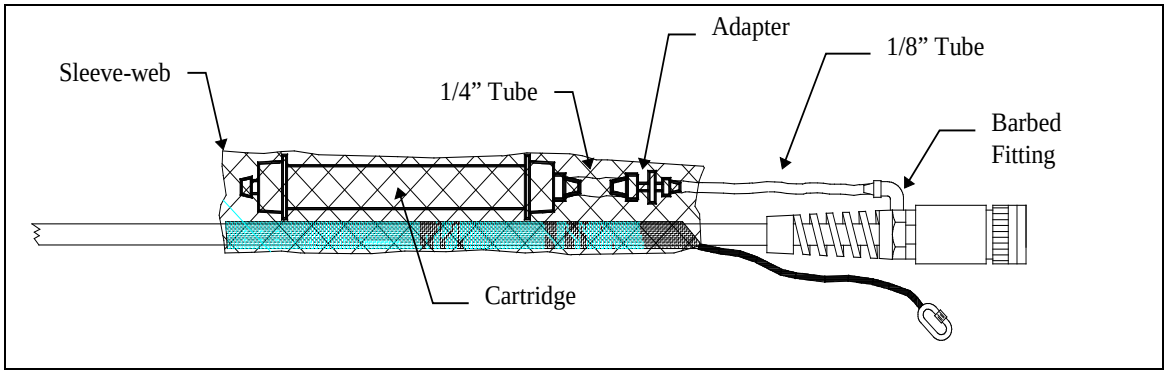
Avoid bending the cables sharply to prevent the vent tube from kinking.

Two desiccant systems are available, a cartridge kit (YSI 6108) and a canister kit (YSI 6109). Either will keep moisture from entering the vent tube. The desiccant cartridge kit mounts directly to the cable and is intended for short-term applications. The desiccant canister contains a larger amount of desiccant and is intended for long term deployment. The desiccant canister kit contains mounting brackets for mounting the canister to a nearby structure. The length of time that the desiccant remains active depends on several factors including heat and humidity.

When using vented level, you must enter altitude and latitude. From the sonde **Main** menu, select **Advanced**, then **3-Sensor**. Enter the altitude in feet and the latitude in degrees of the measurement site. These values need to be accurate within 500 feet and 1 degree, respectively.

For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings. This is especially important for vented level measurements and for sondes with side mounted pressure sensors.

INSTALLING THE CARTRIDGE KIT



1. Place the short length of 1/4” tubing onto the 1/4” side of the 1/8” to 1/4” adapter fitting. Seat firmly.

2. Place the length of 1/8” tubing onto the 1/8” side of the adapter fitting. Seat firmly.

3. Remove one of the plugs from the end of the desiccant cartridge and place the open end of the short length of 1/4” tubing onto the open end of the desiccant cartridge. Seat firmly.

4. Remove the plug from the barbed fitting on the end of the cable and place the open end of the 1/8” tubing onto the cable fitting. Seat firmly.

5. Slide the sleeve-web over the end of the cable and the bail. Work the sleeve-web down the cable and over the cartridge taking care not to unplug the hose that connects the cartridge to the cable.

Optional: Using one of the tie-wraps, secure the hose to the cable taking care not to close off the hose.

The vent end of the cartridge should remain plugged until the sonde is ready for use. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

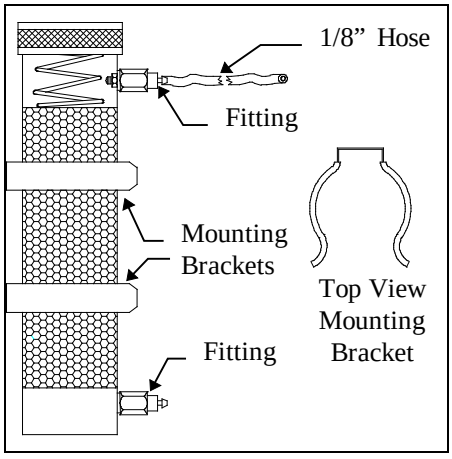
INSTALLING THE CANISTER KIT

1. Remove the 1/8” NPT plugs from the stainless steel fittings on the canister.

2. Install the 1/8” NPT to 1/8” hose fittings into the stainless steel fittings located on the side of the desiccant canister. ***CAUTION***: Do not over-tighten!

3. Place the plugs over the fittings on the canister until you are ready to use the canister.

4. Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.



5. Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

APPENDIX H EMC PERFORMANCE

When using the YSI 6-Series sondes in a European Community (CE) country, please be aware that electromagnetic compatibility (EMC) performance issues may occur under certain conditions, such as when the sonde is exposed to certain radio frequency fields.

If you are concerned with these issues, consult the Declaration of Conformity (page H-2). Specific conditions where temporary sensor problems may occur are listed in this document.

If you are unable to locate the Declaration of Conformity that was shipped with your instrument, contact your local YSI representative, or YSI Technical Support in Yellow Springs, Ohio for a copy of the document. See **Section 9, Warranty and Service Information** for contact information.

DECLARATION OF CONFORMITY

Manufacturer:	YSI Incorporated 1725 Brannum Lane P.O. Box 279 Yellow Springs, OH 45387 USA
Product Name:	6-Series Multi-parameter Water Quality Monitors (Sondes)
Model Numbers:	600R, 600XL, 600XLM, 6820, 6920, 6600, 6600EDS, 600OMS, 600LS, 600DW-B, 6920DW, 6820V2, 6920V2, 6600V2
Conforms to the following:	
Directives:	EMC Directive 89/336/EEC
Applied Standards:	IEC 61326-1 1:1997 including A1:1998, A2:2001 CISPR 11: 1997, A1:1999
Harmonized Standards:	EN55011 :1998, A1:1999 Class B equipment EN61000-4-2 (ESD) EN61000-4-3 (RF radiated immunity) EN61000-4-4 (EFT) EN61000-4-6 (rf conducted immunity) EN61000-4-8 (50 Hz Radiated Susceptibility) FCC Part 15, Subpart B, Sections 15.107a & 15.109a, Class B

Supplementary information:
This device complies with the requirements of the EMC Directive 89/336/EEC and carries the CE mark accordingly.

All performance met class A immunity criteria with the following exceptions:

- Diminished performance may be observed during laboratory procedures, when interfacing to PC, during ESD events that occur directly at the sensors. Permanent diminished performance in sensor performance may occur as a result of severe ESD events that occur at the sensors.
- Diminished performance may be observed with Chlorophyll measurements whenever the dry sonde is subject to radio-frequency fields approaching 3 Volts/meter. Fields nearing 10 Volts/meter can adversely affect measurements of Temperature, Dissolved Oxygen, Chlorophyll, Turbidity, Battery Volts, Ammonium, Nitrate, & Chloride.

Lisa M. Abel
Director, Quality Assurance
Date: 02/19/07

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Yellow Springs, Ohio 45387 USA•Phone 937-767-7241•800-765-4974•Fax 937-767-9353

APPENDIX I CHLOROPHYLL MEASUREMENTS

This is a question and answer guide that will help you optimize performance and trouble-shoot problems. While the YSI 6025 chlorophyll sensor provides a simple and convenient way to estimate phytoplankton concentration in the field, there are significant limitations associated with its use that the user should appreciate fully before beginning field studies. In addition, the chlorophyll systems of YSI 6-series sondes are characterized by a great deal of flexibility from the point of view of the user. Some examples are shown below.

- The data from the chlorophyll sensor can be processed via a sophisticated filtering algorithm that has variable parameters that are input by the user.
- The chlorophyll system can be used in spot sampling applications with a YSI 650 MDS display/logger or a portable computer.
- The chlorophyll system can be used on all sondes for long term deployment applications using cable attachment to a data collection platform.
- The chlorophyll system can be used for long-term deployment applications with the YSI 6-series sondes which contain internal batteries by logging readings directly to sonde memory since they contain 'on board' power.
- A number of calibration options are offered with the YSI chlorophyll system.

This section is designed to help the user attain the maximum possible benefit from the YSI 6025 chlorophyll system by supplementing the discussions of chlorophyll provided in other sections of this manual. (**Section 2.1 --Getting Started, Section 5 - Principles of Operation, and Section 2.10 - Care, Maintenance and Storage**). These are questions that may be asked by a typical user of 6-series sondes with the YSI 6025 chlorophyll sensors. It does not deal with specific instructions for operation of the sondes at the level presented elsewhere in the manual.

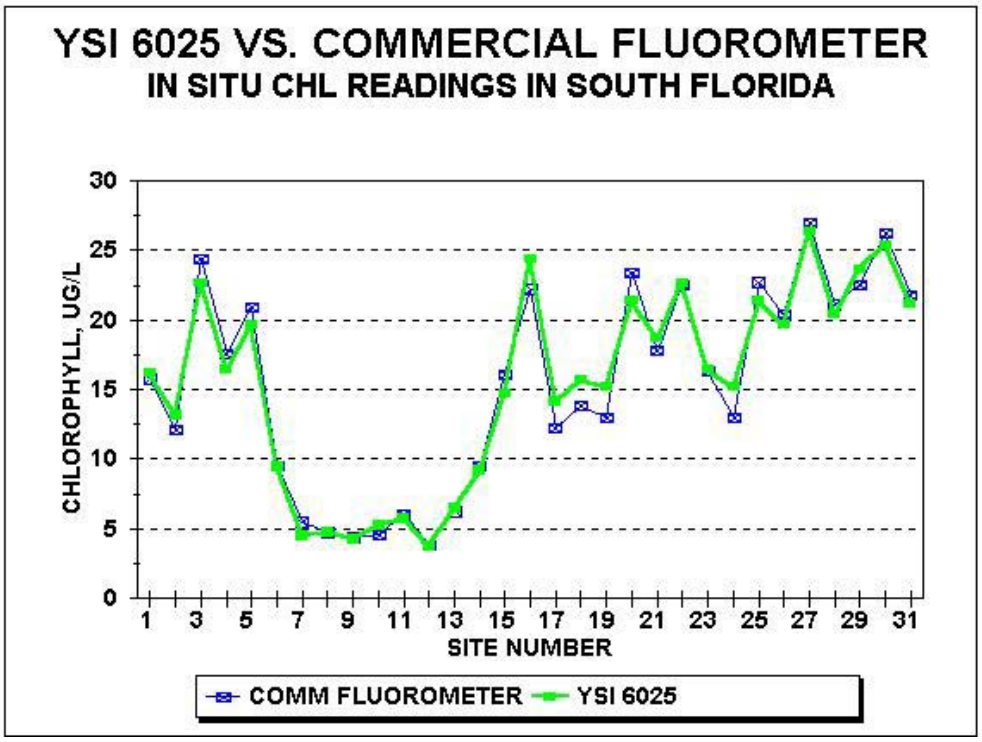
What is the YSI 6025 chlorophyll probe designed to measure?

The YSI sensor is designed to estimate the phytoplankton content of environmental water. Phytoplankton concentrations can be useful in predicting detrimental algal blooms and, indirectly, in determining nutrient loading in environmental applications. The phytoplankton content is estimated by detecting the fluorescence from the chlorophyll in these species *in vivo*, i.e., without disrupting the living cells. Note, however, that the sensor directly measures the fluorescence of all species in the water sample that occurs when they are irradiated with blue light (centered at about 470 nm). Usually most of the fluorescence is due to the chlorophyll in the phytoplankton, but it is important to remember that any compounds which are present in the water sample (either in chemical or biological form), and fluoresce under the optical constraints of the sensor, will contribute to the readings.

What level of accuracy can be expected in my chlorophyll determinations with the YSI 6025?

YSI feels that the user will attain about the same accuracy with the YSI 6025 as with other commercial fluorometers that are designed to carry out *in vivo* determinations of environmental chlorophyll. As for all measurements of this type, the accuracy will be less than that attained if the user collects water samples and analyzes them in the laboratory by disrupting cells and quantifying by spectrophotometric or HPLC analysis of the extracted molecular chlorophyll as described in *Standard Methods*. The relative accuracy of the *in vivo* measurement will be completely dependent on the method of calibration which the user employs (see next question). No matter what calibration technique is used, however, the readings from the YSI

6025 should approximately track the chlorophyll trends in the environmental water being analyzed. For example, if the user deploys the sensor and acquires readings over time at a standard sampling interval (e.g., every 15 minutes), the changes in the chlorophyll data will usually reflect increases or decreases in the phytoplankton content at the site over a long period of time. If the user makes horizontal or vertical profiling spot readings in the same body of water, then the sensor output will usually indicate the presence of more or less phytoplankton at the various sampling sites. The figure below shows the tracking of the chlorophyll content at various sites by both the YSI 6025 and a good quality single parameter commercial fluorometer.

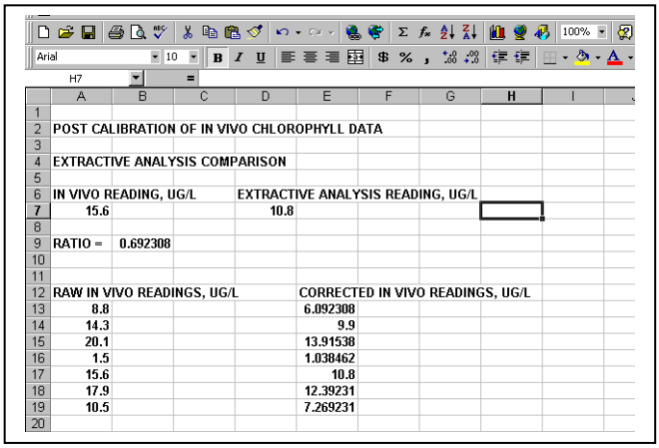


It is important for the user to remember that, because of the limitations defined in this appendix and in **Section 5, Principles of Operation**, YSI is unable to quote an accuracy specification for the *in vivo* measurement of chlorophyll.

What calibration methods are available for the YSI 6025?

There is only one real method of calibration for the 6025 sensor if accuracy is to be assured versus the true chlorophyll content of the water: The sensor must be calibrated with a phytoplankton suspension for which the chlorophyll content is known from extractive analysis in the laboratory. This methodology requires the user to collect water samples of the environmental water in question during sampling or monitoring studies, analyze the samples in the laboratory after cell disruption, and use the chlorophyll values determined by this method to adjust the data acquired with the YSI 6025. Discrete steps for this procedure are found in **Section 5. Principles of Operation**.

Using this method, the field data must be adjusted, either manually or in a spreadsheet, according to the laboratory value. For example, if the YSI 6025 value for a particular site is15.6 ug/L chlorophyll and the laboratory value is 10.8 ug/L, then all of the values for the study should be multiplied by .69 (10.8/15.6). This can easily be done in a spreadsheet, such as Excel, as shown below.



	A	B	C	D	E	F	G	H	I
1									
2	POST CALIBRATION OF IN VIVO CHLOROPHYLL DATA								
3									
4	EXTRACTIVE ANALYSIS COMPARISON								
5									
6	IN VIVO READING, UG/L			EXTRACTIVE ANALYSIS READING, UG/L					
7	15.6			10.8					
8									
9	RATIO =	0.692308							
10									
11									
12	RAW IN VIVO READINGS, UG/L				CORRECTED IN VIVO READINGS, UG/L				
13	8.8				6.092308				
14	14.3				9.9				
15	20.1				13.91538				
16	1.5				1.038462				
17	15.6				10.8				
18	17.9				12.39231				
19	10.5				7.269231				
20									

Note: Be sure to carry out1-point calibration of the sensor before the study, using deionized water to make certain that the sensor reads zero in chlorophyll-free water.

If the sensor is post-calibrated using the values from laboratory analysis of grab samples, will my field data be totally accurate?

No. They will only be as accurate as possible within the limitations of the fluorometry method. The limitations for all *in vivo* chlorophyll determinations described in **Section 5, Principles of Operation** will almost certainly compromise the accuracy of your data even if you employ the best calibration method possible. For example, different phytoplankton species are likely to fluoresce differently *in vivo* even if the actual chlorophyll content is the same. Thus, unless the biological species are perfectly homogeneous with regard to site in a sampling study and with regard to time in a monitoring study, inaccuracy will occur if only a single phytoplankton calibration is performed. In addition, the fluorescence intensity of many phytoplankton types shows a diurnal cycle even though the same amount of material is present. Under this limitation, the time of day at which calibration samples are taken would have to be identical to the time of field measurement for the chlorophyll values determined by the two methods to agree consistently. This level of synchronization is usually not practical.

The key point to remember is that *in vivo* chlorophyll determinations made with any fluorometer are likely to be less accurate than those measured by laboratory analysis of individual samples. The advantages of the *in vivo* method are its convenience and ability to continuously track changes in relative phytoplankton values via indirect fluorescence readings

Can I use a dye standard to calibrate my 6025 chlorophyll sensor to increase the accuracy?

The use of the dye solutions described in the **Principles of Operation** section above will usually not significantly enhance the accuracy of your field readings relative to extractive analysis of grab samples. The primary utility of the dye is to check for sensor drift during deployment by reanalyzing the dye solution after sonde recovery. The use of the 2-point dye calibration procedure may make it easier to quantify the predeployment dye value and, if so, may be preferable. Remember, however, that no real enhancement of sensor accuracy is attained by using the dye as a calibrant.

Will the chlorophyll values determined *in vivo* with the YSI 6025 be reportable for compliance purposes?

Probably not. Because of the limitations on the method outlined above and in the **Section 5, Principles of Operation**, there is always inaccuracy in the *in vivo* method. It might be possible to work with a particular regulatory agency to develop specific correlation protocols between *in vivo* and laboratory-determined chlorophyll values for a particular site, but generation of this methodology is left to the user.

I have seen molecular chlorophyll standards advertised. Can these be used to calibrate the YSI 6025 sensor?

Probably not. The standards are usually only soluble in organic solvents such as acetone that would cause serious damage to the materials used in the YSI 6025 probe. Even if molecular chlorophyll standards that are soluble in aqueous media were available, their fluorescence is not likely to emulate *in vivo* chlorophyll fluorescence any better than the dye standard described above.

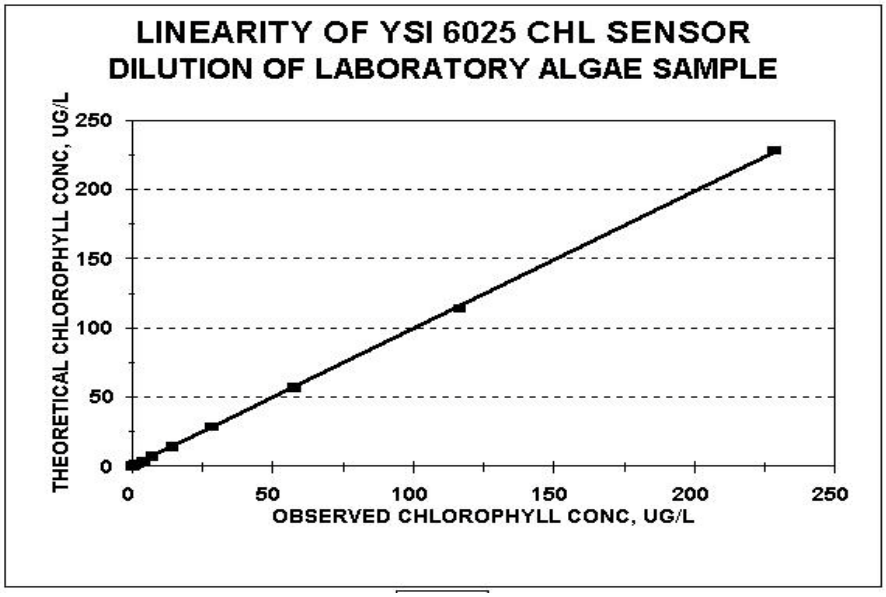
***Caution*:** Do not expose the YSI 6025 to calibrant solutions involving any solvent other than water or very dilute aqueous acid mixtures. Damage to the sensor under these conditions will not be covered under warranty.

The Standard Methods procedure generates values designated as "chlorophyll a". Is this species the reporting unit for the YSI 6025?

No. The different types of chlorophyll cannot be differentiated by the YSI 6025, or by virtually any *in vivo* fluorometer. The values from the YSI 6025 should be reported either as relative fluorescence units or in ug/L of general chlorophyll as long as the method of determination (and its limitations) is specified.

Is the YSI 6025 sensor linear with regard to changes in phytoplankton content?

Yes. The sensor is very linear as evidenced by the following plot that shows the results of a serial dilution of a laboratory algae sample. This linearity on a particular algal species maximizes the ability of the sensor to track relative phytoplankton changes from site to site or during a monitoring study.



What Data Filter settings should I use to obtain the best possible field chlorophyll readings?

As described in **Section 5, Principles of Operation**, some processing of raw chlorophyll data is usually beneficial in terms of outputting values that reflect the "average" chlorophyll at the site. Filter options designed to optimize this data processing are located in the sonde menu structure under both the **3-Sensor** and the **4-Data** Filter selections in the **Advanced** submenu.

For most applications involving both spot sampling and monitoring, the following settings are recommended with regard to data processing:

- In **3-Sensor**, Disable the "Chl Spike Filter" if present
- In **4-Data Filter**, "Enable" the filter.
- In **4-Data Filter**, "Disable" the "Wait for Filter" selection.
- In **4-Data Filter** for chlorophyll, set the Time Constant to 12
- In **4-Data Filter** for chlorophyll, set the Threshold to 1

These default settings will normally produce data that is reflective of the "average" chlorophyll without significantly slowing the response time of the sensor for either sampling or monitoring applications. Increasing the values of the time constant, threshold, or both can further smooth the chlorophyll values. Variation in the default settings should be based on empirical data taken at your particular site.

How often should I calibrate my YSI 6025 sensor?

You should always perform a zero point calibration in deionized water before each use of the YSI 6025 sensor.

Testing at YSI has indicated that the overall sensitivity of the optical system of the YSI 6025 is very stable and is unlikely to show significant drift over time. Thus, if you are using the dye "calibration" method (with its limitations), you may only have to carry out the routine very infrequently (Remember that it is basically only useful as a drift check anyway). In general, you should perform periodic 2-point calibrations using a dye sample more frequently during your initial studies with the YSI 6025 to empirically determine its drift rate and use these results to set up your calibration frequency.

If you are post-calibrating the sensor with phytoplankton suspensions to obtain accurate readings relative to chlorophyll as determined by laboratory extractive analysis, then you will effectively be performing a 2-point calibration for every sampling or monitoring study.

Are there precautions that I should take when acquiring samples for laboratory analysis?

Yes. The key is to obtain a sample which is representative of the water being measured by the YSI 6025 *in vivo*. The mistake most often made is to simply immerse an open bottle in the environmental water. Under these conditions, any macroscopic surface plant or algal matter (which also contains chlorophyll) will also be introduced into the sample even though it is not present in the subsurface zone where the probe is measuring fluorescence. If this happens, your laboratory analysis will always be erroneously high relative to the *in vivo* chlorophyll data from the YSI 6025.

For surface sampling you can minimize this effect greatly by placing the sealed bottle a foot or more below the water surface and only then removing the cap and allowing the container to fill. The cap should then be reinstalled before removing the bottle from the water. A better technique is to acquire commercially

available water sampling devices that are designed specifically to acquire a representative sample at a particular depth.

You should also take precautions to stabilize your samples for transport back to the laboratory. The samples should be kept cool and in the dark (e.g., in an ice chest) until the analytical procedure has begun. Some users prefer to filter the sample in the field and keep the filter pads on ice in the dark during transport.

My environmental sites have a lot of visible floating algae, but my YSI 6025 chlorophyll sensor shows very low readings. What is causing this paradox?

The YSI 6025 is not designed to measure macroscopic algal or plant material that floats on the surface. Rather it measures the fluorescence from the microscopic phytoplankton that is suspended below the surface of the water. It is fairly common to see mats of floating algae on environmental water that has low subsurface phytoplankton concentrations.

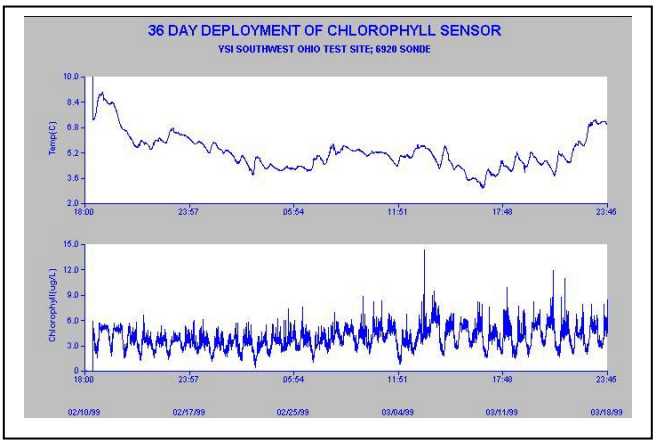
What can I do to obtain the best possible data from my YSI 6025 sensor in sampling studies?

Two factors are most important. The first is to make certain that the readings are stable before manually recording them or logging them to a computer or YSI 650 MDS display/logger. You should visually monitor the readings for at least 1-2 minutes to assure stability after the sonde is immersed. The second factor is that you should always manually activate the mechanical wiper on the sensor after sonde immersion but before beginning the visual monitoring of the readings. The cleaning cycle is necessary to remove bubbles from the optical face, which are certain to cause erroneous readings. If the observed readings appear unusual after the first cleaning cycle, activate the wiper repeatedly to assure that all bubbles are removed. Manual activation of the wiper mechanism is easily accomplished from the Run screen of the 650 MDS.

You should also allow adequate time for the sonde to acclimate to the temperature of the water at the site.

What sort of "noise" level is expected for unattended monitoring studies?

All environmental water is somewhat heterogeneous with regard to phytoplankton content and this factor will cause some noise or jumpiness in long term monitoring studies for chlorophyll. The extent of the noise will be dependent on your site. The data from a typical 36-day deployment at a YSI test site (lake in southwestern Ohio) is shown in the figure below as a reference. Note the diurnal cycle in the data which is likely due to the photoinhibition of chlorophyll fluorescence as discussed in **Section 5, Principles of Operation.**

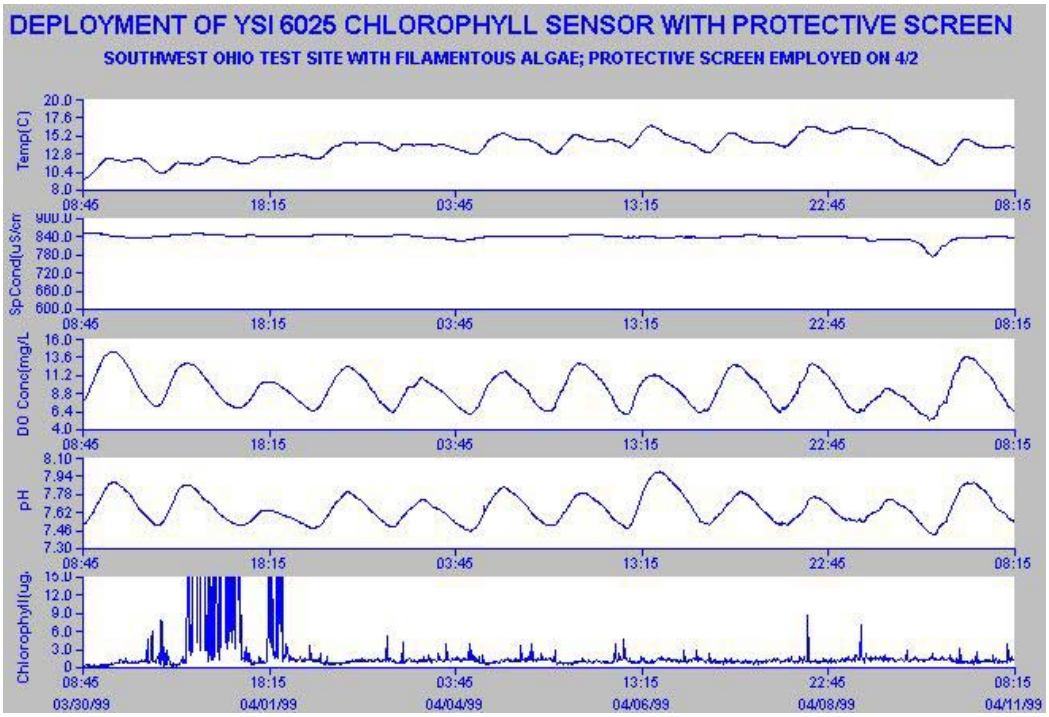


Note also that your may observe less or more noise at your site with no compromise in sensor performance. Occasional spikes during a monitoring study are normal and usually simply indicate the transient passage of a large phytoplankton particle over the optical face during the time of sampling.

If you consistently observe periods in your monitoring study where the data is clearly unreliable due to a large number of very high spikes, then you may have to take additional precautions to minimize the effect (see next question).

My unattended monitoring data shows a large number of chlorophyll spikes that clearly do not reflect the average phytoplankton content of the water. What is causing this effect and is there anything I can do to minimize it?

This effect, shown in the initial chlorophyll readings in the figure below, can be caused by the presence of subsurface macroscopic filamentous algae.



The flexible algal strands can become attached to the wiper arm and sometimes are resident on the probe optics even after a cleaning cycle. The key to decreasing the spiking effect is to minimize the free algae, which is present in the probe compartment of the sonde. This can sometimes be accomplished by encasing the sonde guard in standard fiberglass window screen wire which is available at most hardware stores and then anchoring the screen with rubber bands as shown in the picture below.

Note the significant improvement in the overall noise level of the readings after the screen was installed on 4/2/99. However, there is no guarantee that this solution will completely solve spiking problems caused by macro algal species. In some applications, it may be necessary to clean the sonde and probes at a frequent interval to minimize the number of erroneous readings.

CAUTION: If the installed screen becomes completely clogged with algal filaments, it can create an isolated environment within the probe compartment which does not accurately reflect the water quality readings of the overall water at the site. Users should periodically remove the screen and check for immediate changes in parameters such as dissolved oxygen and pH. If gross changes appear in the data after removal of the screen, then the screen is likely to be retarding water flow to the sensors and should be cleaned at more frequent intervals.

Another factor that can contribute to repeated spikes in the user's chlorophyll data is wiper malfunction so that the wiper assembly parks over the probe optics. This problem is usually due to the edges of the fluorescent wiper becoming coated with nonfluorescent material such as sediment that, in turn, prevents the sonde software from detecting the wiper movement. If the spikes are due to this factor, then the problem will be corrected by manually cleaning the wiper edges so that the fluorescent surface is restored.

How often should I change my mechanical wiper?

For sampling and monitoring studies, YSI recommends periodic inspection of the wiper to assure that it is not fouled with silt or biological material. If any of these symptoms is noted, debris should be removed from the wiper, particularly the edges where the pad meets the wiper assembly. If the wiper pad is abraded or damaged in anyway, the wiper assembly should be changed immediately. YSI also recommends that the wiper be changed as a precaution prior to each long term monitoring study. Spare wipers are available in the YSI 6024 Wiper Kit. In addition, users who wish to replace only the pad of the wiper assembly can purchase the YSI 6144 Optical Wiper Pad Kit.

***Caution*:** When replacing the wiper, be sure that you do not rotate the wiper arm after it is tightened to the shaft. This may damage the internal motor/gearbox mechanism and could void your warranty.

Do I have to worry about the effect of variable temperature on my field readings?

This factor is definitely a consideration depending on the level of reliability you require if the water at your site is at a significantly different temperature from that of calibration. YSI studies show that, while the optics and electronics of the sensor show very little temperature effect, the fluorescence of phytoplankton samples does vary significantly with temperature. Generally, the chlorophyll in biological samples shows increased fluorescence at lower temperatures with a factor of 1-2 % per degree Celsius. In practice, this means that if, for example, the calibration temperature is 25 C and the water temperature at the site is 10 C, the observed chlorophyll readings will be erroneously high by 15-30 %. The "Chl Tempco" factor in the **Advanced|Sensor** menu can be used to partially compensate for this error, if the user has some knowledge of the temperature effect on the particular phytoplankton at the site. The factor can be empirically determined by bringing a sample of the environmental water to the laboratory and determining its fluorescence at ambient temperature and low temperature. (Simply cool the sample in a refrigerator for the latter reading.) The calculated factor can then be entered into the sonde software. See the example in **Section 5, Principles of Operation**.

I suspect that my YSI 6025 chlorophyll sensor is not performing properly. What should I do before contacting YSI Technical Support to facilitate resolving the problem?

You should perform two diagnostic tests to help YSI personnel determine if the YSI 6025 is malfunctioning.

First, determine whether the wiper system of the probe is working by interfacing the sonde containing the sensor to a computer on a 650 MDS display/logger, beginning a **Discrete Sample** study, and manually activating the wiper. Determine if the wiper turns at all, and, if it does, whether it reverses direction and parks approximately 180 degrees from the optical face.

Second, determine the sensitivity of the probe by measuring its sensitivity under factory default conditions in a dye solution prepared as described in **Section 5, Principles of Operation**. Place the sonde containing the probe in question into the dye solution. Enter the Calibrate menu and then the Chlorophyll submenu and choose a "1-point Chl ug/L" protocol. Instead of entering a value at the prompt, type the work "uncal" and press **Enter**. This returns the sonde software to the factory default sensitivity. Begin a **Discrete Sample** study and record the chlorophyll ug/L reading displayed. Finally, place the sonde in deionized water and record the chlorophyll ug/L reading displayed in **Discrete Sample**.

Record the results of these two tests and report them, along with any other symptoms, to a YSI Technical Support Group representative.

APPENDIX J PERCENT AIR SATURATION

The term “Percent Air Saturation” (abbreviated in many applications to “Percent Saturation”) is a common parameter for expressing the state of the oxygenation of environmental water and is widely used by YSI and other manufacturers during the calibration of oxygen sensors. Basically the "Percent Saturation" value is simply a surrogate for the partial pressure of oxygen in the medium (air or water) being measured. In this light, it is important to understand that, to our knowledge, all environmental oxygen sensors (either electrochemical or optical) directly measure the pressure of oxygen – not the concentration. Thus, the “Percent Saturation” value from an environmental instrument reflects the directly measured parameter for the system, with the concentration in mg/L being easily calculated from known equations involving Percent Saturation, Temperature, and Salinity.

Because the “Percent Saturation” parameter can be expressed by two different conventions, there can be confusion around the use of the term. This section is designed to minimize that confusion by defining each of these conventions and to provide instructions for configuring your 6-series sonde so that you will have a choice as to which of the conventions is used. **It is very important to note, however, that no matter which of the conventions is employed (in YSI or competitive instrumentation), the values of dissolved oxygen in mg/L, the units usually reported, will be identical and unaffected by the choice of DO % convention.**

Note also that the discussion below applies equally to data obtained from both the YSI Rapid Pulse membrane-covered polarographic oxygen sensor and the YSI ROX optical dissolved oxygen sensor.

The “DOsat %” Convention

In the first convention, used for many years in YSI handheld and laboratory instruments and in 6-series sondes, the "% saturation" value at the time of calibration in air reflects the value of the barometer that was input in the calibration protocol. If the parameter “DOsat %” is active in your 6-series Report menu, then this convention is being used. Effectively, this convention provides a value of water oxygenation that can be carried out by air exposure, with the value referenced to having the air at exactly 1 atmosphere (760 mm Hg or 101.3 kPa). A “DOsat %” value of 89 means that the water contains 89 % of the oxygen that could be dissolved if the water was sparged with air that had a total pressure of 1 atm. For example, for an air calibration in the mountains at a typical barometric pressure of 630 mm Hg, the YSI “DOsat %" value at calibration would read 82.9 % (630/760 * 100). If the sensor did not drift electrochemically and the sonde was taken to a location where the atmospheric pressure was exactly 760 mm Hg (e.g., sea level), then the “DOsat %” reading in air (or air-saturated water) would change to 100 % (760/760 *100) because there is more total oxygen in the air at the lower elevation. (Note that the ratio of oxygen to other gases in the air is effectively independent of the barometer or altitude, but the absolute amount of oxygen changes with barometer or altitude.) If the water at both sites is assumed to have a temperature of 20 C (where water exposed to water-saturated air at exactly 760 mm Hg is 9.09 mg/L), then the mg/L value would be 7.54 mg/L (0.829 * 9.09) in the mountains and 9.09 mg/L (1.00 * 9.09) at sea level. Thus, to calculate mg/L values at any site after calibration using this convention, the observed “DOsat %” value is simply multiplied by the Standard Methods or ISO table values that correspond to 100 % at various temperatures and salinities.

The “DOsat %Local” Convention

In the second convention, used for many years by other multiparameter instrument companies and by many European handheld instrument manufacturers, the "% saturation" value is always set to exactly 100 % at the time of calibration regardless of the barometer value that was input. The software of the instrument “remembers” the barometric pressure input at the time of calibration for use in later calculation of the DO concentration in mg/L. Effectively, this convention provides a value of water oxygenation that can be carried out by air exposure with the value referenced to the local air pressure. The 100 % value at calibration for this convention basically reflects the fact that this is the most oxygen that can be dissolved in water for this location at the time of calibration. In late 2001 (Version 2.13 of 6-series code), this dissolved oxygen convention was added to the YSI 6-series software through the use of the parameter “DOsat %Local”. For example, for an air calibration in the mountains at a typical barometric pressure of 630 mm Hg, the “DOsat %Local” value at calibration would read 100.0 % and the value of 630 mm would be stored in instrument memory. If the sensor did not drift electrochemically and the sonde was taken to a location where the atmospheric pressure was exactly 760 mm Hg (e.g., sea level), then the “DOsat %Local” reading in air (or air-saturated water) would change to 120.6 % (760/630 * 100) because there is more total oxygen in the air at the lower elevation.

The mg/L value for water saturated air or air-saturated water assuming a temperature of 20 C at both sites would change from 7.54 mg/L (1.00 * 630/760 * 9.09) in the mountains to 9.09 mg/L (1.206 * 630/760 * 9.09) at sea level. Thus, to calculate mg/L values at any site after calibration using this convention, the "DOsat %Local" value is multiplied by the ratio of the barometric pressure at calibration to 1 atm (table conditions) and then by the table value as shown above. Note that the same mg/L values are obtained at both sites for the “DOsat %” and “DOsat %Local” conventions even though the "percent saturation" values are significantly different.

It is important to note that the convention specified for "% saturation" by the British (and EU) standard REQUIRES that the local barometric pressure be read for every DO data point taken after calibration. Under this convention, a sensor should ALWAYS read 100 % saturation when in water-saturated air or air-saturated water. Since the software of most instruments does not “know” the barometer at any time after calibration, **neither of the conventions described above complies with the British standard.**

Calibrating Using the mg/L Mode

When the user performs a mg/L calibration, no barometer input will be required. Instead, values of “DOsat %Local” reported after the calibration will be based on the barometer reading input by the user at the time of the last “DO %” calibration. If the user requires the best possible accuracy for “DOsat %Local” values after calibration then a “DO %” calibration (with correct barometer input) should be performed immediately before the “DO mg/L” calibration. If a “DO %” calibration has never been carried out, then the software will assume that the barometer at the last calibration was exactly 760 mm Hg.

When the user performs a mg/L calibration, values of “DOsat %” will be calculated as they are in the current software, i.e., the input mg/L value will be divided by the theoretical mg/L value at 1 atmosphere (found in the Std. Methods Table) to yield the reported “DOsat %” value. For example, if a value of 7 mg/L is entered at a temperature value of 21 C (where 100 % saturation at 1 atmosphere is 8.915), the “DOsat %” value will be (7/8.915) or 78.5. DO % readings for field readings are carried out in exactly the same way – find the Table value in mg/L which corresponds to the environmental salinity and temperature and divide the environmental DO mg/L by it.

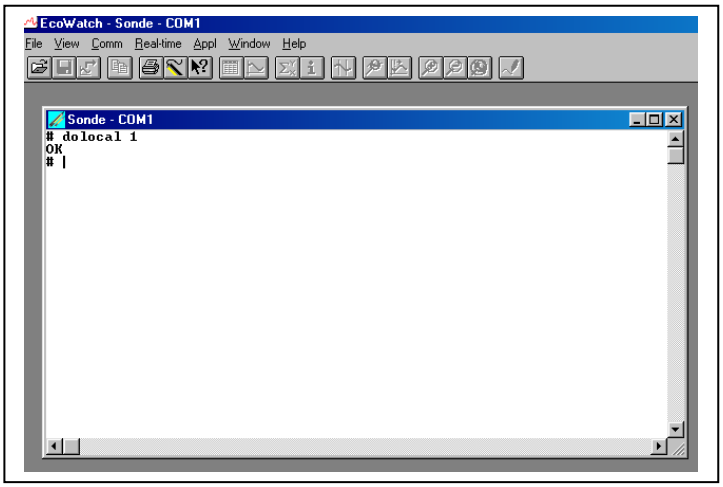
If the user performs a mg/L calibration and “DOsat %Local” is active in the Report, the software will, as noted in above, assume that the barometer reading at calibration is the same as that at the last “DOsat %” calibration. Thus, after the calibration procedure is complete “DOsat %” values calculated as described above are then multiplied (in the software) by a factor of (760/BP) to yield the corresponding "DOsat

%Local" values. For example, assume that the temperature of the calibration standard is 21 C (where air saturation at 760 mm Hg is 8.915 mg/L) and that the oxygen content of the solution has been determined to be 7 mg/L by Winkler titration. Assume also that the local barometric pressure was entered as 700 mm at the last "DOsat %" calibration. After the new "DO mg/L" calibration, the "DO mg/L" value will be set to 7.00, the "DOsat %" value will be set to (7/8.915)*100 = 78.5, and the "DOsat %Local" will be set to (760/700)*78.5 = 85.2.

NOTE: As pointed out above, it is important to realize that UNLESS THE BAROMETRIC PRESSURE IS KNOWN FOR EVERY DO READING AFTER CALIBRATION, the values of "DOsat %" and "DOsat %Local" will be incorrect if the barometric pressure has changed since calibration. Thus, even if the barometer had been input at the time of a mg/L calibration (a method used by some instrument manufacturers, the values of "DOsat %Local" will still not be exactly accurate after calibration.

Activation of the "DOsat %Local" or "ODOsat %Local" Parameter

On receipt of your sonde or after upgrading your 6-series software to Version 2.13 or higher, the "DOsat %Local" or "ODOsat %Local" parameter will NOT appear in your Report menu. To activate the parameter, it is necessary to exit the menu structure of the sonde software to the command line prompt ("#"). The "#" sign appears after you press **Esc** from the Main menu and then answer "Y" to the question, "Exit menu (Y/N)"? Once the "#" prompt is shown on the display, type "dolocal 1" as shown in the display below and press **Enter**. The screen will show "OK" to indicate that the action was successful and return another "#" sign as shown. Then type "menu" at the second "# sign and press **Enter** to return to the sonde software menu structure.

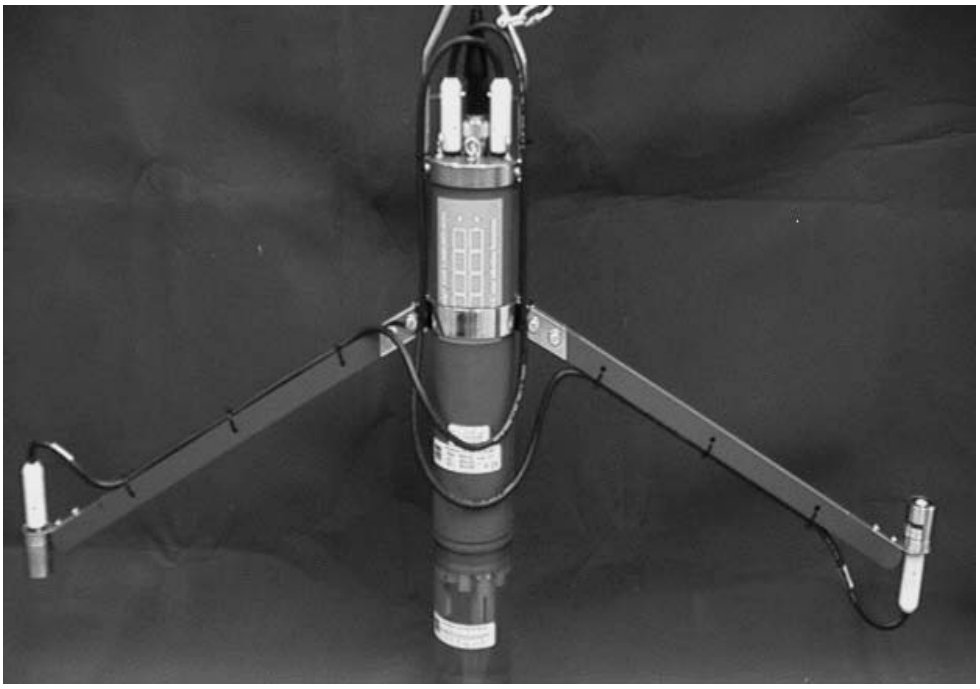


After taking the above action the parameter "DOsat %Local" or "ODOsat %Local", depending on the type of DO sensor used in your sonde, will be present in your Report menu. If you want to remove the parameter, return to the "#" prompt, type "dolocal 0", and press **Enter.**

APPENDIX K PAR SENSOR

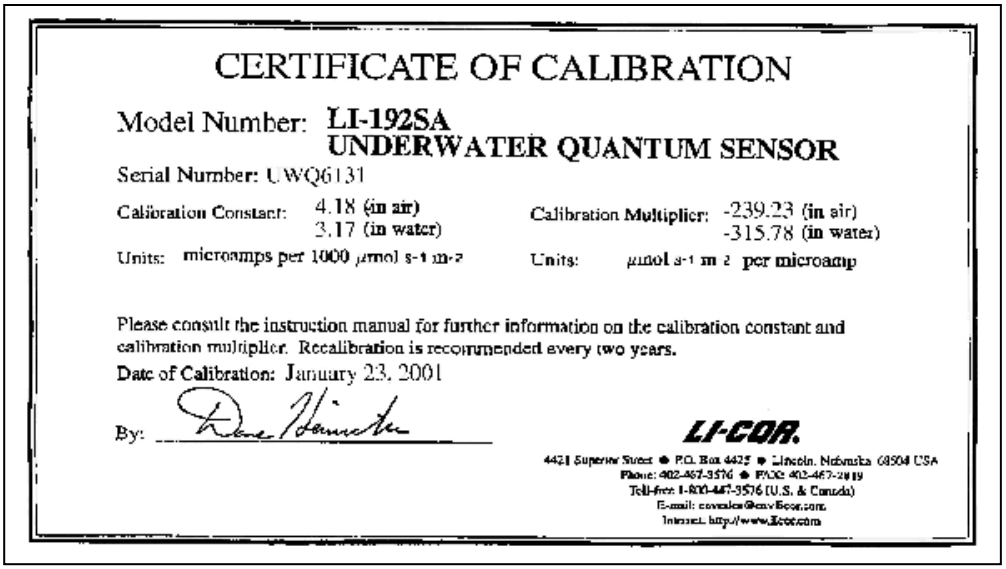
Some users of the YSI 6600-style sonde (6600V2-2, 6600EDS V2-2, and 6600V2-4) may wish to incorporate a photosynthetically active radiation (PAR) sensor into their field monitoring equipment. This sensor can be added to the 6600 in the form of a special product engineered by Endeco/YSI. This section is designed to give potential users of this type of system an idea of how it is configured and the steps necessary to acquire and log PAR data with the modified sonde.

Li-Cor PAR sensors are required for the 6600 modification and these can either be supplied to Endeco/YSI by the user or can be purchased from Endeco/YSI as part of the system cost. These sensors are then attached to "arms" which extend from the sonde and their output cables are connected to the sonde PCB through the top of the sonde as shown in the following picture. The picture shows the installation of two sensors (one pointing up, the other pointing down), but it is also possible to use a single PAR sensor if the user prefers that configuration.



Each Li-Cor PAR sensor can be individually configured by Endeco/YSI with an internal circuit to have variable sensitivities: high (usually employed for "upwell" or downward pointing sensors) or low (usually employed for "downwell" or upward pointing sensors). After sensitivity configuration, the outputs of the sensors are fed into the main sonde PCB thorough ISE ports ISE3 and ISE4. The ports can, in turn, be configured in the **Sensor** and **Report** menus to show the presence of the PAR sensors (PAR1 for ISE3) and PAR2 for ISE4), allowing the user to view or internally log their data during profiling or unattended monitoring studies.

If the default settings of the sonde software are accepted, the PAR outputs will simply be in millivolts. However, it is also possible to enter the calibration constants provided by Li-Cor into the sonde software through the **Advanced|Sensor** menu. If these constants are entered then the units viewed or logged from the PAR sensors will be shown as "Photosynthetic Photon Flux Density" with units of umoles/second/m^2. A typical Certificate of Calibration as supplied by Li-Cor is shown below:



CERTIFICATE OF CALIBRATION

Model Number: LI-192SA
UNDERWATER QUANTUM SENSOR

Serial Number: UWQ6131

Calibration Constant: 4.18 (in air)
3.17 (in water)

Calibration Multiplier: -239.23 (in air)
-315.78 (in water)

Units: microamps per 1000 μmol s-1 m-2

Units: μmol s-1 m-2 per microamp

Please consult the instruction manual for further information on the calibration constant and calibration multiplier. Recalibration is recommended every two years.

Date of Calibration: January 23, 2001

By: _____

LI-COR.

4421 Superior Street ● P.O. Box 4425 ● Lincoln, Nebraska 68504 USA
Phone: 402-467-3576 ● FAX: 402-467-2819
Toll-free 1-800-447-3576 (U.S. & Canada)
E-mail: envsales@envlicor.com
Internet: http://www.licor.com

To set up your special PAR 6600-style sonde, follow the steps below in the sonde menu structure:

Enter the **Sensor** menu and then press the proper number for ISE3. Then choose PAR1 from the submenu and press **Esc** to return to the Sensor menu. If you have two PAR sensors, repeat the process to activate PAR2 for the ISE4 port.

```
------------Sensors enabled---------
1-(*)Time           7-( )ISE3 NONE
2-(*)Temperature    8-( )ISE4 NONE
3-(*)Conductivity   9-( )ISE5 NONE
4-(*)Dissolved Oxy  A-(*)Turbidity
5-(*)ISE1 pH        B-(*)Chlorophyll
6-(*)ISE2 Orp       C-(*)Battery

Select option (0 for previous menu): 7
```

```
--------------Select type-------------
-
1-( )ISE3 NH4+
2-( )ISE3 NO3-
3-( )ISE3 Cl-
4-( )ISE3 PAR1

Select option (0 for previous menu): 4
```

After activating the sensors, enter the **Report** menu and make certain that the PAR selections are active as shown below:

```
-------------Report setup--------------
1-(*)Date           C-( )DOchrg
2-(*)Time hh:mm:ss  D-(*)pH
3-(*)Temp C         E-( )pH mV
4-(*)SpCond uS/cm   F-(*)Orp mV
5-( )Cond           G-(*)PAR1
6-( )Resist         H-(*)PAR2
7-( )TDS            I-(*)Turbid NTU
8-(*)Sal ppt        J-(*)Chl ug/L
9-(*)DOsat %        K-( )Fluor %FS
A-( )DOsat %Local   L-(*)Battery volts
B-( )DO mg/L

Select option (0 for previous menu): 0
```

Finally, if you want to present your PAR data in photon flux density (umoles/second/m^2), enter the **Advanced|Sensor** menu as shown below and enter values for the PAR gain settings after consulting the Certificate of Calibration obtained from Li-Cor for each sensor.

```
------------Advanced sensor------------
1-TDS constant=0.65
2-Pres psi=0
3-DO temp co %/C=1.1
4-DO warm up sec=40
5-( )Wait for DO
6-Wipes=1
7-Wipe interval=5
8-SDI12-M/wipe=1
9-Turb temp co %/C=0.3
A-(*)Turb spike filter
B-Chl temp co %/C=0
C-( )Chl spike filter
D-PAR1 gain=1
E-PAR2 gain=1

Select option (0 for previous menu):
```

The number that should be entered is derived from the Calibration Multiplier in the Certificate of Calibration supplied with each sensor, but the exact entry requires some modification of the Certificate value. First, the Calibration Multiplier "in water" should be selected. Second, the negative sign should be dropped from the number prior to entry. Finally, the number should be divided by either 100 (Low Sensitivity Hardware) or 1000 (High Sensitivity Hardware) prior to entry. Thus, if the two identical sensors characterized by the above Certificate were present in the sonde, but were configured for both low sensitivity (PAR1) and high sensitivity (PAR2), the entered gain numbers should be 3.1578 for PAR1 and 0.31578 for PAR2, with both numbers derived from the –315.78 value on the Certificate. As noted above, once these entries are made, the viewed and logged PAR values will be in umoles/second/m^2 of Photon Flux Density.

```
------------Advanced sensor------------
1-TDS constant=0.65
2-Pres psi=0
3-DO temp co %/C=1.1
4-DO warm up sec=40
5-( )Wait for DO
6-Wipes=1
7-Wipe interval=5
8-SDI12-M/wipe=1
9-Turb temp co %/C=0.3
A-(*)Turb spike filter
B-Chl temp co %/C=0
C-( )Chl spike filter
D-PAR1 gain= 3.1578
E-PAR2 gain=0.31578

Select option (0 for previous menu):
```

For additional information about modification of you 6600 to include a PAR sensor configuration, contact Endeco/YSI (1-800-363-3269).

APPENDIX L PROTECTIVE ZINC ANODE

Shipbuilders have used the concept of the “sacrificial anode” for decades to minimize corrosion damage to all metallic parts of ships. Elemental zinc is commonly used as the sacrificial anode because it is more easily oxidized than most other metals. Thus, a replaceable block of zinc is installed in electrical contact to other metals on the ship which are susceptible to salt water corrosion and the zinc is preferentially oxidized (or corroded), preventing damage to the ship hull and other metal components.

The concept of the sacrificial anode can also be utilized for 6-series sondes which are deployed in corrosive media – particularly seawater or brackish estuarine water. In this case, the zinc anode is used to prevent corrosion of the stainless steel connector found on the top of most 6-series sondes. The instructions below outline the installation procedures for the zinc anode offered by YSI as Model 6182 Kit. The anode enclosed in the kit is divided into two C-shaped sections as shown in Figure 1 below. Note that each section has a flat on one end.

Figure 1

Installing the Zinc Anode on 600R, 600XL, 6820V2-1, and 6820V2-2 Sondes

NOTE: Before beginning the installation, be sure to clean the sonde connector of mud, sediment sediments, barnacles, etc. It is important for the surface to be clean in order to make good electrical contact to the zinc anode.

Figure 2

Figure 3

1. Using a large regular blade screwdriver, bend the bracket outward to the angle shown in Figure 2.
2. Position the zinc anode flat towards the bracket and squeeze together with pliers if necessary as shown in Figure 3.
3. Use the screwdriver to bend the bracket back to vertical.
4. Secure zinc halves with the cable tie.

Installing the Zinc Anode on 6000upg, 6600V2-2, 6600EDS V2-2, 6600V2-4, 6920V2-1, 6920V2-2, 600XLM, and 600 OMS V2-1 Sondes:

NOTE: Before beginning the installation, be sure to clean the sonde connector of mud, sediment sediments, barnacles, etc. It is important for the surface to be clean in order to make good electrical contact to the zinc anode.

Figure 4

For the 6600-style sondes, first remove the pressure-relief battery lid and set it aside for later installation. The position the zinc anode onto the sonde connector as shown in Figure 4 above, leaving a small gap between the bottom of the anode and the top of the sonde. Make sure that the flat sides of the anode parts are next to the battery lid as shown.

Figure 5

For 6920-style sondes, make certain that fresh batteries have been installed and that the battery lid is in place. Then position the zinc anode on the connector making certain that the flat is toward the bail hardware (Figure 5 above) and that the anode is installed below the threads on the connector.

Figure 6

For the 600XLM and 600 OMS V2-1 sondes, the user will be required to manually cut a second flat on the other end of the C-shaped anode sections. Then make certain that fresh batteries have been installed in the sonde. Finally, with the battery lid in place, install the anode sections on the connector being certain that the flats are on the sides where the bail attaches to the battery cover and that the assembly is below the threads of the connector. The proper installation is shown in Figure 6 above.

For all sondes, after the sections of the anode have been put in place, squeeze the halves together, using pliers if necessary for a tight fit.

Finally secure the anode to the connector using a cable tie which is included in the Model 6182 kit.

NOTE: The zinc anode collar must be removed before you can replace the batteries for 600XLM, 600 OMS V2-1, and 6920-style sondes. A new plastic cable tie will be needed to re-secure the zinc.

WARNING: The zinc anode must not interfere with the ability to properly attach of the pressure cap to the sonde connector – the cap MUST be threaded all the way down to prevent leaks into the connector. Therefore, the anode must also NOT be placed over the threads of the connector.

APPENDIX M ROX OPTICAL DO SENSOR

This appendix is in the format of "frequently asked questions", is designed to allow users to optimize the performance and the trouble-shooting of problems for your YSI 6150 ROX Optical dissolved oxygen probe by supplementing the discussion of optical dissolved oxygen measurement that is provided in the other sections of this manual (**Getting Started, Basic Operation, Principles of Operation, and Maintenance**).

How does the ROX Optical DO Sensor work?

In general, optical dissolved oxygen sensors from a variety of manufacturers are based on the well-documented principle that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with carefully-chosen chemical dyes. The 6150 sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk about 0.5 inches in diameter. This dye-containing disk will be evident on inspection of the sensor face. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation. For most lifetime-based optical DO sensors (including the YSI 6150), this Stern-Volmer relationship (((Tzero/T) – 1)) versus O_2 pressure) is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression rather than the simple linear regression used for most polarographic oxygen sensors. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

Each YSI sensor module (the assembly which is attached to the face of the probe by three screws) is factory-calibrated over a range of 0-100 percent oxygen to quantify the relationship of its luminescence lifetime as a function of oxygen pressure. The Stern-Volmer parameters from this data are then fit to a third order regression equation ($ax^3 + bx^2 + cx$) and values of a, b, and c determined. These coefficients, along with the luminescence lifetime at zero oxygen pressure (Tzero), are provided to the user in coded form with each sensor membrane module or probe/sensor module combination. If you install a replacement sensor membrane assembly (YSI 6155) on your existing probe, you will be required to enter these coded constants into the sonde as described in the instructions which come with the 6155 prior to the use of the sensor. If you have purchased a probe/membrane combination, i.e. a new 6150 Optical DO sensor, the constants are already stored in your probe and will automatically be transferred to your sonde when the sensor is installed.

What are the key advantages of the ROX sensor over membrane-covered polarographic sensors?

The ROX dissolved oxygen sensor has three key advantages over the YSI Rapid Pulse sensor:

1. The set-up and maintenance of the ROX sensor is much easier since there is no membrane or electrolyte to be changed by the user.

2. Testing indicates that the ROX sensor is significantly less susceptible to field drift.

3. The ROX sensor is automatically wiped during field studies to eliminate effects of fouling. The Rapid Pulse sensor can be wiped, but only if a 6600EDS V2-2 sonde is used.

In addition, the ROX DO sensor has NO flow dependence, giving it a large advantage over systems which utilize steady-state membrane covered polarographic oxygen sensors. This advantage is minimal relative to the YSI Rapid Pulse technology which is effectively flow-independent in monitoring studies and shows only minimal flow dependence (ca. 3%) in continuous-on sampling studies.

What is the warranty period for the ROX DO Sensor?

The probe is warranted for 2 years and the sensor membrane assembly is warranted for 1 year. See **Section 9** of this manual for details of the YSI warranty policy.

What sondes can use the ROX DO Sensor?

The ROX Sensor can be used with any existing or new YSI 6-series sonde which contains an optical port. Currently available sondes which support the use of the ROX sensor are 600 OMS V2-1, 6820V2-1, 6820V2-2, 6920V2-1, 6920V2-2, 6600V2-2, 6600EDS V2-2, and 6600V2-4 which were manufactured after June 1999. If you have an older sonde with an optical port and want to determine whether it will support the use of the ROX sensor, contact YSI Technical Support. They will be able to evaluate the compatibility of your sonde with the ROX sensor by giving you a few simple software commands to issue at the "#" sign of your sonde.

If I want to use the new ROX DO Sensor with my existing sonde, what else do I have to do?

In order to use the ROX technology on an existing YSI 6-series sonde, you must do the following:

- Upgrade the firmware in your sonde from the YSI Website (ysi.com) to Version 3.00 or higher.
- Upgrade your EcoWatch for Windows PC software from the YSI Website to Version 3.18 or higher.
- Upgrade the firmware in your 650 MDS Display/Logger from the YSI Website to Version 1.18 or higher.

Note if your sonde was manufactured after June 1999, there is no need to return your existing sonde to YSI. After carrying out the software upgrades described in detail in the instruction sheet shipped with the 6150 Probe, you will be able to simply install the ROX sensor in your optical port and begin taking readings. If your sonde was manufactured prior to June 1999, then you should contact YSI Technical Support to determine if it is compatible with the ROX sensor

Can I measure dissolved oxygen with both ROX Optical and Rapid Pulse Polarographic sensors in the same sonde?

No. If you try to activate both the ROX and Rapid Pulse sensors in the sonde **Sensor** menu, only the last sensor activated will be functional.

What are the key differences between the ROX Optical and Rapid Pulse DO sensors?

The key differences between the sensors are as follows:

- The 6150 optical sensor has no flow dependence even in continuous operation during spot sampling studies while the 6562 polarographic sensor can exhibit up to 3% flow dependence.

- For the 6562 polarographic sensor, users must calibrate the sensor by different methods for sampling (Discrete Sample) and monitoring (Unattended Sample) by activating or deactivating the "Autosleep RS-232" feature found in the **Advanced|Setup** menu. The calibration of the 6150 optical sensor is the same for both sampling and monitoring applications and no changes in the "Autosleep RS-232" feature are required.

- It is possible to calibrate the 6562 polarographic sensor ONLY in oxygen-containing media at a single point. The 6150 optical sensor can be calibrated at either a single point in oxygen-containing media OR at two points, a zero-oxygen medium and an oxygen-containing medium. This allows users to maximize the accuracy of the 6150 sensor at low oxygen levels if they feel it to be necessary.

Is the ROX DO Sensor calibrated at YSI prior to shipment to the customer?

Yes. Factory calibration is required because, unlike all other sensors for YSI 6-series sondes, the response of the ROX Optical DO sensor is not linear relative to the species being measured. This non-linearity requires that the sensor be factory-calibrated at a number of oxygen values and the data fit to a third-order regression. The three constants and the sensor value at zero dissolved oxygen which define this regression analysis are automatically stored in the sensor at the time of factory-calibration. It is important to note that these constants are a function of the sensor membrane installed on the 6150 probe and NOT a function of the probe, i.e., the constants reflect the characteristics of the sensor membrane and NOT the probe. When a 6150 probe is purchased from YSI, it already has a sensor membrane installed and the constants of that membrane are transferred automatically to the sonde PCB when the sensor is run for the first time. After transfer, the constants can be viewed by accessing the **Advanced|Cal Constants** menu as described below in a separate question/answer.

Note, however, that, even with the factory calibration, the user still should perform a calibration after receipt of the sensor as described below in order to assure that the typical accuracy specification is met.

How do I calibrate my ROX DO sensor?

The ROX DO sensor is typically calibrated in the same way as the YSI Rapid Pulse sensor – a single point calibration in either air-saturated water, water saturated air, or a solution whose oxygen content has been determined by Winkler titration. Like the Rapid Pulse sensor, the ROX sensor can be calibrated in either the air-saturation mode (requiring a local barometer value input) or in concentration mode (requiring an input of oxygen content in mg/L).

It is also possible to carry out a 2-point calibration of the ROX sensor with the other point being zero oxygen content. NOTE, HOWEVER, THAT YSI DOES NOT RECOMMEND THE 2-POINT CALIBRATION UNLESS (A) YOU ARE CERTAIN THAT THE SENSOR DOES NOT MEET YOUR ACCURACY REQUIREMENTS AT LOW DO VALUES AND (B) YOU ARE OPERATING UNDER CONDITIONS WHERE YOU ARE CERTAIN TO BE ABLE TO GENERATE A MEDIUM WHICH IS TRULY FREE OF OXYGEN.

The calibration methods and recommendations for the ROX sensor are provided in detail in Section 2 of this manual and in the instruction sheet which you received with the ROX probe. The key is to remember that the single point calibration option will provide data of acceptable accuracy for the vast majority of users and it should be used in most cases.

Should I calibrate my ROX sensor in water-saturated air or air-saturated water?

Studies at YSI have shown that the sensor shows effectively the same reading in air-saturated water and water-saturated air. Thus, if the calibration is carried out properly, either medium can be used with confidence. The advantage of air-saturated water is the quick equilibration of the sonde sensors relative to thermal and humidity factors; the disadvantages are that you will require an aquarium pump, an air-stone, a large vessel to immerse the sonde in the air-saturated water, and you must sparge the water for at least 1 hour prior to calibration to assure that it is air-saturated. The advantage of using water-saturated air is that the calibration can be carried out in the cup supplied with the sonde and it can be done somewhat faster than the air-saturated water method. Note, however, that if you use water-saturated air as the calibration method, you should still wait at least 15 minutes after placing the sensors in the calibration vessel to assure thermal equilibration between the temperature and ROX DO sensors.

The bottom line is that either method will give good results as long as the considerations above are followed. The air-saturated water method may be slightly preferable if you have the equipment because of the assured equilibration, but the advantage is slight.

If I want to perform a 2-point calibration, how do I generate a zero-oxygen medium?

Two methods are generally used to provide a zero-oxygen environment:

1. Place the ROX sensor in a vessel which is filled with a flowing inert gas such as nitrogen gas

2. Place the ROX sensor in an aqueous solution of sodium sulfite at a concentration of approximately 2 g/L)

The following qualifiers apply to the zero point calibration methods:

- If you use nitrogen gas for the zero point calibration, you should make certain that the vessel you use has a SMALL exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.

- If you use sodium sulfite solution for the zero point calibration, you should make up the solution at least 2 hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. You should also transfer the sodium sulfite solution rapidly from its container to the sonde calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the calibration cup to the sonde to prevent diffusion of air into the vessel.

Whichever method you use, it is very important that you wait at least 10-12 minutes and until the readings are stable for at least 2 minutes before confirming the zero point calibration entry.

If I make a mistake in a 2-point calibration, will my sensor always be inaccurate?

No. You can either perform a new 2-point calibration with better control of the conditions or you can return to the factory default calibration by using the “uncal” command as described below.

- Select **Calibrate** from the **Main** menu, then **Optic T Dissolved Oxy**, and then run any of the ODOsat % or ODO mg/L options.

- When prompted for the input of a barometer or a concentration value, type the word “uncal” and press **Enter** if your sonde is attached to a computer. If your sonde is attached to a 650 MDS, when prompted for input, hold down the **Enter** key and press the **Esc** key.

Either procedure will reset your 6150 calibration constants to the previously input values associated with your sensor membrane.

How often should I calibrate my ROX sensor?

Our experience is that, even though the drift of the ROX sensor is minimal, it is prudent to calibrate the sensor in air-saturated water or water-saturated air prior to each deployment or field sampling study. The calibration takes very little time and should be carried out to (a) maintain the best possible accuracy for the sensor and (b) to assure that the sensor is working properly prior to proceeding to the field.

I notice that, during Discrete Sample studies, there is a lag between when I begin the sampling and when ROX DO readings actually appear on the display. What is causing this effect?

The lag between starting the study and actually seeing data is due to the fact that the readings of all optical sensors, including ROX DO, are frozen during the sensor wiping sequence. If the sonde has not been used for more than a minute, it will be in the “sleep” mode and, under these conditions, all optical sensors will automatically wipe the first time a Discrete Sample command is issued. The extent of the lag varies depending on how many optical sensors are present in the sonde and will be about 15 seconds per optical sensor. Thus, lag will be about 15 seconds for a sonde with two optical sensors and about 1 minute for a sonde with four optical sensors.

How does the ROX sensor deal with fouling in field studies?

The ROX sensor has a wiper similar to those used on all YSI optical sensors (turbidity, chlorophyll, rhodamine WT, and blue-green algae) which removes fouling from the sensor membrane. The wiper activates just prior to each measurement point in a long term study. In addition, the wiper can be activated manually from a PC keyboard or from a 650 MDS handheld logger to remove bubbles from the sensor membrane prior to spot sampling measurements.

What color wiper should be used with the ROX DO sensor?

Because the probe is digital, you can use any color wipers with the 6150 ROX sensor. In fact, if you are using the ROX sensor in the “T” port of a 6600EDS V2-2 sonde, you should use the white EDS wiper for the application. However, just to be consistent, YSI recommends that you use black wipers for the ROX sensor like those supplied with the probe for all 7non-EDS applications. The wiper is a wear item and a spare is provided with each probe along with a 0.05” hex key to loosen/tighten the wiper set screw. Black wiper packs, YSI 6625, can be ordered from YSI Technical Support or Customer Service. Alternatively, users who choose to change only the wiper pad can purchase the YSI 6144 Optical Wiper Pad Kit.

What is the response time of the ROX DO sensor?

On transfer to field water, typically the ROX sensor will reach 90% of its final value in less than 30 seconds – slightly faster than the YSI Rapid Pulse sensor. Note, however, that the response time of the ROX probes varies slightly from sensor module to sensor module.

How often should I change my ROX sensor membrane assembly?

YSI recommends that you change your membrane assembly every 12 months. The membrane assembly is simple to install and can be purchased from YSI Technical Support as the YSI 6155 Optical DO Sensor Replacement Kit.

Since the sensor is non-linear and the non-linearity is not identical for all sensors, how do I take this factor into account when I replace the sensor membrane assembly?

As described in the instruction sheet for the 6155 Optical DO Sensor Replacement Kit, you will be required to enter coded constants which are provided with the new membrane assembly into the sonde software. The process takes only a few minutes as briefly described below.

Locate the Calibration Code Label which is attached at the end of the instruction sheet provided and note the five numbers which are listed as K1 through K4 and C on the sticker. These five numbers contain the calibration code for this particular sensor membrane.

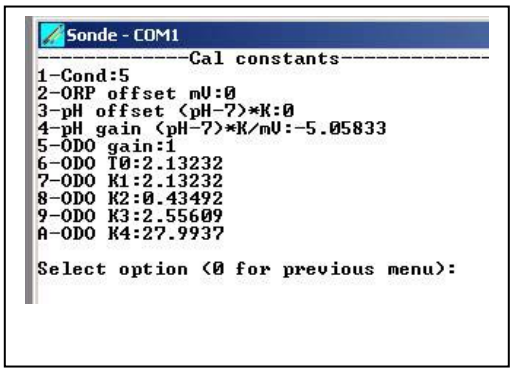
From the **Main** sonde menu, select **Calibrate|Optic T- Dissolved Oxy a**nd then select the "**3-Enter Cal Sheet**" entry. You will be prompted to enter the K1 value from the sticker. After carefully entering K1, press **Enter** to confirm the entry and then you will be prompted to enter the value of the next number. Values of K2-K4 and C should be entered in similar fashion to K1, pressing **Enter** to confirm each entry. If no error message is encountered after confirming the C value, then you have made all entries correctly and the proper constants will be transferred automatically into the sensor system for correct calculation of dissolved oxygen. If an error message is displayed after entry of C, then you have made an error (or errors) in entering the code. Following the error message you will be returned to the **Calibrate** menu from which you should again enter the K1-K4 and C numbers until the entries have been made correctly

Note that it is good idea to place the instruction sheet which contains the calibration information IN A SAFE PLACE in the unlikely event that you need to reenter it later.

How can I be sure that my calibration coefficients have been entered correctly and confirm that they are being read correctly by the sonde software?

One of the five constants (C) which you entered in coded form is a check sum value associated with the values of K1-K4 and will prevent acceptance of the constants if typographical errors are made in their entry by the user. Thus, it is not possible to make an incorrect entry of the coded constants.

After entry of the coded constants in the **Calibrate** menu, the actual constants associated with the regression fit of your particular membrane can be viewed by accessing the **Advanced|Cal Constants** menu as shown below – the regression constants are ODO K2-ODO K4 and the value at zero oxygen is K1 as shown below. Note that these constants will not appear at this location until the sonde has been run for the first time with the 6150 ROX sensor installed.



How should I store my ROX sensor when it is not in use?

When the 6150 sensor is not in field use, it MUST BE STORED IN A MOIST ENVIRONMENT, i.e., either in water or in water-saturated air with storage in water being preferable. If the sensor membrane is allowed to dry out by exposure to ambient air, it is likely to drift slightly at the beginning of your next deployment unless it is rehydrated. Thus, to make the use of the sensor as simple as possible, remember to store it WET whenever possible. The easiest storage method is to use the protective plastic cap (and enclosed sponge) which was on the probe at receipt. If you have retained this cap/sponge, then simply soak the sponge in water and replace the cap on the probe tip. Inspect the sponge every 30 days to make sure it is still moist. Alternatively, you can remove the probe from the sonde and place it directly in water (making sure that the water does not evaporate over time or leave the probe in the sonde and make certain that the calibration cup has an atmosphere which is water-saturated by placing approximately ½ inch of water in the bottom of the cup and then sealing it snugly to the sonde.

If I have inadvertently allowed my ROX sensor membrane to dry out for several days, is it ruined?

No. The sensor membrane can easily be rehydrated using the following basic procedure:

> Place approximately 400 mL of water in a 600 mL beaker or other similar glass vessel – do NOT use plastic vessels – and heat the water on a thermostatted hotplate or in an oven so that a consistent temperature of 50+/- 5 C is realized. Place the probe tip containing the sensor membrane in the warm water and leave it at the elevated temperature for approximately 24 hours. Cover the vessel if possible to minimize evaporation. After rehydration is complete, store the probe in either water or water-saturated air prior to calibration and deployment.

Once the rehydration has been performed, the sensor should be returned to its original performance specification.

Can I use alcohol or other organic solvents to clean my sensor membrane?

Absolutely NOT**.** Alcohol will dissolve the outer paint layer of the membrane assembly and other organic solvents will likely dissolve the dye itself. Under NO circumstances should you use organic solvents to clean your sensor membrane. The best method of cleaning the membrane is just to gently wipe away any fouling with a piece of lens cleaning tissue which has been moistened with water only.

I have a few pinholes in the outer paint layer of my sensor membrane so that I can see small spots of light from the probe. Will this light leakage affect the performance of my ROX sensor?

No. A few small pinholes in the outer paint layer will have no discernable effect on sensor performance. However, if there are a lot of holes or if they are relatively large (1 mm or greater in diameter), then there might be a minor compromise of sensor accuracy relative to the factory calibration. Under these latter conditions, YSI would recommend replacing the membrane assembly.

Is there any effect of ambient light on the readings from the ROX DO sensor?

Under all normal operating conditions, the ROX sensor is unaffected by ambient light, even if there are a few minor scrapes or pinholes in the protective paint layer of the sensor membrane. These conditions include exposure to room lighting during calibration and set-up and deployments in all clarities of water as long as the ROX sensor is pointed down or on its side. Our studies indicate that only if the ROX sensor is exposed directly to bright sunlight with the probe pointed upward will the readings be affected significantly. Thus, there is no reason to worry about the effect of ambient light unless your deployment sight is very unusual and requires that the sensor be pointed directly upward in shallow water with no probe

guard. It is also important to note that if the membrane is exposed to bright sunlight for extended periods, i.e., more than 60 minutes, the life of the membrane may be reduced due to photo-bleaching of the dye. Thus, make certain that you protect the membrane from bright sunlight during any storage and/or transportation to your deployment site.

Is there any effect of wiping the sensor membrane on the ROX DO readings?

Yes, there is a minor effect. Typically the optical DO reading will drop by about 1.5 % immediately after a wipe which is activated during Discrete Sample studies. After 12 seconds, the reading has typically returned to within 0.7 % of the final reading. It takes about 30 seconds for complete recovery of the ROX optical DO reading after the sensor membrane is wiped. This effect is due to the physical contact of the wiper pad with the membrane since it is not observed when the wiper assembly is removed and only the wiper shaft turns when a wipe command is issued.

Will this wiping effect cause inaccuracy in my Unattended study readings with the ROX DO sensor since I will be calibrating without wiping, but logging readings after the ROX sensor has been wiped?

The error will be minor in any case, but will vary depending on what other optical probes you have installed in your sonde. Since the effect is physical as described in the previous question, the longer it takes to log a reading after the ROX sensor has wiped, the less error there will be relative to the calibration. Under the worst case scenario, the user has ONLY a ROX sensor present with an ODO Time Constant setting of 12 seconds as set in **Advanced|Data Filter**. This set-up means that readings will be logged internally 12 seconds after the wipe has terminated and, under these conditions, there will be a typical error of 0.7 % of the reading – within the sensor specification of 1 % of the reading. This error will be further reduced if other optical probes are present since the time for them to be wiped plus their time constants will further increase the time between the wiping of the ROX sensor and the time a point is logged to internal memory. (Note that the ROX sensor is ALWAYS WIPED FIRST, no matter what optical port it is installed in as long as you have Version 3.04 or later of firmware installed in your sonde.) The extent of the error would thus be greatest with a 6920V2-1 running ROX DO only, less with a 6600-type or 6920V2-2 sonde running ROX DO and turbidity, still less with a 6600-type sonde running ROX DO and chlorophyll or BGA (since the time constant these other optical sensors is 24 seconds) and least for a 6600V2-4 sonde containing ROX DO and 3 other optical sensors. Typical errors in Unattended readings from this wiping effect are 0.7% for a sonde with only a ROX sensor and 0.3% for a sonde with a ROX and one other optical sensor. There is no discernible error for a 6600V2-4 sonde with a ROX and three other optical sensors.

Can I reduce the small error from the wiping effect?

Yes. By increasing the Time Constant value for ODO in the **Advanced|Data Filter** menu, the error will definitely be reduced. For example, with a ROX DO probe as its only optical sensor, typically your error would be reduced from 0.7% to 0.3% by increasing the ODO Time Constant from 12 to 24 seconds. Naturally, however, this will have an adverse effect on the battery life of your sonde for deployments so you should balance this factor relative to the small DO error which will be observed if you leave the Time Constant at 12 seconds.

I will be installing a ROX sensor in my 6600EDS V2-2 sonde along with another optical probe. Does it matter in which optical port I place the ROX sensor?

Yes. You should always install the ROX probe in the center (T) port of the 6600EDS V2-2 sonde and substitute the special EDS wiper for the black wiper that came with the ROX probe. The other optical probe should be installed in the outer optical port (c) with a standard wiper assembly. This installation

protocol will prevent the stiff EDS auxiliary brush which cleans the pH or pH/ORP sensor from abrading the outer paint layer of the ROX membrane. There should be no problem with the EDS wiper parking correctly even though it is white (rather than the standard black wiper supplied with the probe) since an internal Hall Effect device controls the parking in the ROX sensor.

How can I tell if my ROX sensor is not functioning is not functioning properly?

There are two factors which would indicate that your sensor is not operating up to specifications. The first is that you are observing software errors when you attempt to calibrate the ROX probe. The second is that your data (either in Discrete Sample or Unattended Sample studies becomes jumpier than normal. In addition, if your membrane surface has suffered major damage as evidenced by loss of more than 10% of the outer paint layer, then, even if the readings are stable and you do not see calibration errors, it is probably time to change your membrane assembly.

What should I do if I don't think that my ROX sensor is functioning properly?

The first step is to remove the membrane assembly from the probe face as shown in Section 2.10.2 of this manual and make certain that there is no moisture present under the membrane assembly. If moisture is present, gently remove it with lens cleaning tissue and, if possible, by a compressed air stream. Make certain that the O-ring which seals the membrane assembly to the probe face is in the groove and undamaged. Then replace the membrane assembly and evaluate the probe performance. If the performance has not improved, consult YSI Technical Support for advice on how to proceed next.

APPENDIX N NMEA APPLICATIONS

6-series sondes can be configured to output NMEA formatted strings (National Marine Electronics Association). Some equipment manufactures in the marine industry use this as their native method of communication. This appendix is designed to help personnel who are already trained in NMEA applications implement this specialized protocol for their sondes.

NMEA APPLICATIONS SET UP

There are two ways to get NMEA strings from the sonde:

1. Send the NMEA command from the command prompt.
2. Enable start up to NMEA in the advanced setup menu.

Once the sonde is outputting NMEA strings you can return to the command prompt by sending an <ESC> character. Note that if you enabled start up to NMEA, the sonde will revert back to outputting NMEA strings after you reset or power cycle the sonde.

The format of the NEMA string is:

$YSI,Code #1,Value #1,Code #2,Value #2,...*XX

Code is the YSI defined parameter code. (See table below)
Value is the value of the parameter.
XX is a check computed by a bitwise "exclusive or" (xor) of all characters between $ and *, non inclusive. The XX value is sent as 2 hexadecimal nibbles, most significant nibble first.

Here's an example:

$YSI,1,4.44,7,10,18,7.00*4E

In this case we have:
Temp C 4.44
SpCond uS/cm 10
pH 7.00

PARAMETER CODES

The list below shows all possible parameters that can be output from a 6-series sonde. Note that depending on the sonde type you have, some parameters may not be available. In addition, some parameters are for internal testing only and will not be available, but are listed for completeness.

```
Code Name and units
---- --------------
 51, Date d/m/y
 52, Date m/d/y
 53, Date y/m/d
153, Date
 54, Time hh:mm:ss
  1, Temp C
  2, Temp F
  3, Temp K
  6, SpCond mS/cm
```

```
  7, SpCond uS/cm
  4, Cond mS/cm
  5, Cond uS/cm
  9, Resist MOhm*cm
  8, Resist KOhm*cm
 94, Resist Ohm*cm
 10, TDS g/L
 95, TDS Kg/L
 12, Sal ppt
 14, DOsat %
200, DOsat %Local
 15, DO mg/L
 96, DOchrg
209, Cl2 mg/L
210, Cl2chrg
 20, Press psia
104, Press psir
 21, Press psig
111, Press psi
 22, Depth meters
 23, Depth feet
118, Flow ft3/sec
166, Flow ft3/min
167, Flow ft3/hour
168, Flow ft3/day
164, Flow gal/sec
119, Flow gal/min
165, Flow gal/hour
120, Flow Mgal/day
121, Flow m3/sec
169, Flow m3/min
170, Flow m3/hour
171, Flow m3/day
122, Flow L/s
172, Flow AF/day
123, Volume ft3
124, Volume gal
173, Volume Mgal
125, Volume m3
126, Volume L
174, Volume acre*ft
 18, pH
 17, pH mV
 19, Orp mV
 48, NH4+ N mg/L
108, NH4+ N mV
 47, NH3 N mg/L
106, NO3- N mg/L
101, NO3- N mV
112, Cl- mg/L
145, Cl- mV
201, PAR1
202, PAR2
 37, Turbid NTU
203, Turbid+ NTU
193, Chl ug/L
194, Chl RFU
```

```
204, Rhodamine ug/L
211, ODOsat %
214, ODOsat %Local
212, ODO mg/L
215, BGA-PC cells/mL
216, BGA-PC RFU
217, BGA-PE cells/mL
218, BGA-PE RFU
 98, Gnd Hz
 99, Scale Hz
100, Prescmp
 32, Density kg/m3
 28, Battery volts
```

APPENDIX O SPECIFICATIONS

SONDE SPECIFICATIONS

6600V2-2 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, Ammonium, Nitrate, Chloride, and Depth (shallow, medium, deep, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 75 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, Rapid Pulse DO with a 60-second DO warm up time, and two optical probes other than ROX DO active. Approximately 70 days at 20 C at a 15 minute logging interval, with temperature, conductivity, pH/ORP, ROX Optical DO, and one other optical probe active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6600EDS V2-2 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, and Depth (shallow, medium, deep, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, and BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water

Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, and optical sensors
-10 to +60 °C for pH, pH/ORP, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: Approximately 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 75 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, Rapid Pulse DO with a 60-second DO warm up time, and two optical probes other than ROX Optical DO active. Approximately 70 days at 20 C at a 15 minute logging interval, with temperature, conductivity, pH/ORP, ROX Optical DO, and one other optical probe active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6600V2-4 SONDE

Available Sensors Temperature, Conductivity, Dissolved Oxygen (ROX Optical), pH, ORP, and Depth (shallow, medium, deep, shallow vented). Four total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 656 feet (200 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, and optical sensors
-10 to +60 °C for pH, pH/ORP, and optical sensors

Material: PVC, Stainless Steel

Diameter: 3.5 inches (8.9 cm)
Length: 19.6 inches (49.8 cm) with no depth, 21.6 inches (54.9 cm) with depth
Weight: Approximately 7 pounds (3.18 kg) with depth and batteries but no added bottom weight

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 C-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 55 days at 20 C at a 15 minute logging interval, and temperature, conductivity, pH/ORP, ROX Optical DO, Turbidity, Chlorophyll, and BGA-PC (or BGA-PE) sensors active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6920V2-1 SONDE

Available Sensors Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, three ion selective electrodes (ammonium, nitrate, chloride), and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.

Operating Environment Medium: fresh, sea, or polluted water
Temperature: -5 to +50 °C for most sensors
Depth: 0 to 200 feet (61 meters)

Storage Temperature: -40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors
-10 to +60 °C for pH, pH/ORP, ISE, and optical sensors

Material: Polyurethane, PVC, Stainless Steel

Diameter: 2.9 inches (7.4 cm)
Length: Approximately 18.25 inches (46.4 cm) with no depth.

Weight: Approximately 3.74 pounds (1.7 kg).

Computer Interface: RS-232C, SDI-12

Internal logging memory size: 384 kilobytes (150,000 individual parameter readings)

Power: 8 AA-size Alkaline Batteries or External 12 VDC

Battery Life: Approximately 30 days at 20 °C at 15 minute logging interval with temperature, conductivity, pH/ORP, and Rapid Pulse DO with a 40-second DO warm up time, and one optical probe other than ROX optical DO active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6920V2-2 SONDE

Available Sensors	Temperature, Conductivity, pH, ORP, one ion selective electrode (ammonium, nitrate, or chloride), and Depth (shallow, medium, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors -10 to +60 °C for pH, pH/ORP, ISE, and optical sensors
Material:	Polyurethane, PVC, Stainless Steel
Diameter:	2.9 inches (7.4 cm)
Length:	Approximately 18.25 inches (46.4 cm) with no depth, 19.63 inches (49.9 cm) with depth
Weight:	Approximately 3.74 pounds (1.7 kg)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	8 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 32 days at 20 C at a 15 minute logging interval with ROX Optical DO, another optical sensor (turbidity, chlorophyll, Rhodamine WT, BGA-BC, or BGA-PE), temperature, conductivity, and pH active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

6820V2-1 SONDE

Available Sensors	Temperature, Conductivity, Rapid Pulse Dissolved Oxygen, pH, ORP, three ion selective electrodes (ammonium, nitrate, chloride), and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE). Note that Rapid Pulse and ROX DO sensors cannot be activated simultaneously.
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)

Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors -10 to +60 °C for pH, pH/ORP, ISE, and optical sensors
Material:	PVC, Stainless Steel
Diameter:	2.9 inches (7.4 cm)
Length:	Approximately 16.82 inches (42.7 cm) with no depth; 18.2 inches (46.2 cm) with depth
Weight:	Approximately 3.4 pounds (1.5 kg)
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Computer Interface:	RS-232C, SDI-12
Power:	External 12 VDC (8 to 13.8 VDC)

6820V2-2 SONDE

Available Sensors	Temperature, Conductivity, pH, ORP, one ion selective electrode (ammonium, nitrate, or chloride), and Depth (shallow, medium, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors -10 to +60 °C for pH, pH/ORP, ISE, and optical sensors
Material:	Polyurethane, PVC, Stainless Steel
Diameter:	Approximately 2.9 inches (7.4 cm) 2.9 inches (7.4 cm)
Length:	Approximately 16.82 inches (42.7 cm) with no depth; 18.2 inches (46.2 cm) with depth
Weight:	Approximately 3.4 pounds (1.5 kg)**.**
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	External 12 VDC (8 to 13.8 VDC)

600XLM SONDE

Available Sensors	Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only) pH, ORP, Depth (shallow, medium, shallow vented).
Operating Environment	Medium: fresh, sea, or polluted water Temperature :-5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH and pH/ORP -10 to +60 °C for pH and pH/ORP sensors
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	21.3 inches (54.1 cm) with no depth; 23.3 inches (59.2 cm) with depth
Weight:	1.48 pounds (0.67 kg) (with batteries, without bottom weight)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	4 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 30 days at 20 C at a 15 minute logging interval with temperature, conductivity, pH/ORP, and Rapid Pulse DO with a 60-second DO warm up time active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

600XL SONDE

Available Sensors	Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP, Depth (shallow, medium, shallow vented)
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH and pH/ORP -10 to +60 °C for pH and pH/ORP sensors
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	15.25 inches (38.7 cm) from bottom of probe guard to top of connector with no depth and no weight. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)
Weight:	1.07 pounds (0.49 kg) (without bottom weight)

Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Computer Interface:	RS-232C, SDI-12
Power:	External 12 VDC (8 to 13.8 VDC)

600R SONDE

Available Sensors	Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 (61 meters)
Storage Temperature:	-40 to +60 °C (without pH installed) -10 to +60 ° C (with pH installed)
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	14.75 inches (37.5 cm)) from bottom of probe guard to top of connector with no depth and no weight. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)
Weight:	1.1 pounds (0.50 kg) without weight
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	External 12 VDC (8 to 13.8 VDC)

600QS SONDE

Available Sensors	Temperature, Conductivity, Dissolved Oxygen (Rapid Pulse Polarographic Only), pH, ORP, Depth (medium)
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 (61 meters)
Storage Temperature:	-40 to +60 °C (without pH installed) -10 to +60 ° C (with pH installed)
Material:	PVC, Stainless Steel

Diameter:	1.65 inches (4.2 cm)
Length:	14.75 inches (36.20 cm) from bottom of probe guard to top of connector with no depth. Add 2 inches (5.1 cm) for depth; add 0.75 inches (1.9 cm) for bottom weight)
Weight:	1.1 pounds (0.65 kg) without weight
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	External 12 VDC (8 to 13.8 VDC)

600 OMS V2-1 SONDE

Available Sensors	Temperature, Conductivity, and Depth (shallow, medium, shallow vented). One total optical sensor (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE)
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C (without optical sensor installed) -10 to +60 °C (with optical sensor installed)
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	21.25 inches (54.0 cm) from top of connector to bottom of probe guard without depth, bottom weight, and battery option. Add 3.75 inches (9.5 cm) for battery option. Add 2.0 inches (5.1 cm) for depth. Add 0.75 inches (1.9 cm) for weight
Weight:	1.78 pounds (0.81 kg) with depth and batteries but without bottom weight
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	4 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 30 days at 20 C with a 15 minute logging interval and temperature, conductivity, and ROX Optical DO active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

600LS SONDE

Available Sensors	Temperature, Conductivity, and shallow vented depth.
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C Depth: 0 to 30 feet (15 meters)
Storage Temperature:	-40 to +60 °C
Material:	PVC, Stainless Steel
Diameter:	1.65 inches (4.2 cm)
Length:	Approximately 15 inches (38.0 cm) from top of connector to bottom of probe guard, bottom weight, and battery option. Add 0.75 inches (1.9 cm) for weight
Weight:	Approximately1.10 pounds (0.50 kg)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	4 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 180 days at 20 C with a 30 minute sample interval. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

SENSOR SPECIFICATIONS

The following are typical performance specifications for each sensor.

Non-Vented Level – Deep

Sensor Type.....Stainless steel strain gauge
Range.....0 to 656 feet (200 m)
Accuracy.....+/- 1 ft (0.3 m)
Resolution.....0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Non-Vented Level - Medium

Sensor Type.....Stainless steel strain gauge
Range.....0 to 200 ft (61 m)
Accuracy.....+/- 0.4 ft (0.12 m)
Resolution.....0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Non-Vented Level - Shallow
Sensor Type.....Stainless steel strain gauge
Range.....0 to 30 ft (9.1 m)
Accuracy ..... +/- 0.06 ft (0.018 m)
Resolution.....0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Vented Level - Shallow
Sensor Type.....Stainless steel strain gauge
Range.....0 to 30 ft (9.1 m)
Accuracy, 0-30ft .....+/- 0.01 ft (0.003 m)
Resolution.....0.001 ft (0.001 m)
Temperature Range -5 to 45 C

Temperature
Sensor Type.....Thermistor
Range.....-5 to 50 °C
Accuracy.....+/- 0.15 °C
Resolution.....0.01 °C
Depth……200 meters

Rapid Pulse Dissolved Oxygen, % saturation
Sensor Type.....Rapid Pulse - Clark type, polarographic
Range.....0 to 500 % air saturation
Accuracy.....0-200 % air saturation, +/- 2 % of the reading or 2 % air saturation, whichever is greater
200-500 % air saturation, +/- 6 % of reading
Resolution.....0.1 % air saturation
Temperature Range -5 to 50 C
Depth……200 meters

Rapid Pulse Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type..... Rapid Pulse - Clark type, polarographic
Range.....0 to 50 mg/L
Accuracy.....0 to 20 mg/L, +/- 2 % of the reading or 0.2 mg/L, whichever is greater
20 to 50 mg/L, +/- 6 % of the reading
Resolution.....0.01 mg/L
Temperature Range -5 to 50 C
Depth……200 meters

ROX Optical Dissolved Oxygen, % saturation
Sensor Type.....Optical, Luminescence Lifetime
Range.....0 to 500 % air saturation
Accuracy .....0-200 % air saturation, +/- 1 % of the reading or 1 % air saturation, whichever is greater
200-500 % air saturation, +/- 15 % of reading; Relative to Calibration Gases.
Resolution.....0.1 % air saturation
Temperature Range -5 to 50 C
Depth…… 61 meters

ROX Optical Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type..... Optical, Luminescence Lifetime
Range.....0 to 50 mg/L
Accuracy.....0 to 20 mg/L, +/- 1 % of the reading or 0.1 mg/L, whichever is greater
20 to 50 mg/L, +/- 15 % of the reading; Relative to Calibration Gases.
Resolution.....0.01 mg/L
Temperature Range -5 to 50 C

Depth…… 61 meters

pH
Sensor Type.....Glass combination electrode
Range.....0 to 14 units
Accuracy.....+/- 0.2 units
Resolution.....0.01 units
Temperature Range -5 to 50 C
Depth……200 meters

ORP
Sensor type..... Platinum button
Range.....-999 to +999 mV
Accuracy.....+/-20 mV in redox standard solutions
Resolution.....0.1 mV
Temperature Range -5 to 60 C
Depth……200 meters

Turbidity
Sensor type..... Optical, 90 ° scatter, with mechanical cleaning
Range..... 0 to 1000 NTU
Accuracy.....+/- 2% of the reading or 0.3 NTU (whichever is greater), in YSI AMCO-AEPA standards
Resolution.....0.1 NTU
Temperature Range -5 to 50 C
Depth…… 61 meters

Chlorophyll
Sensor type..... Optical, fluorescence, with mechanical cleaning
Range..... Approximately 0 to 400 µg/L Chl; 0-100 Relative Fluorescence Units (RFU)
Accuracy..... No specification provided
Linearity..... R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 500 ug/L
Detection Limit…..Approximately 0.1 ug/L Chl (determined using cultures of Isochrysis sp. and chlorophyll a concentration determined through extractions).
Resolution.....0.1 µg/L Chl; 0.1 RFU
Temperature Range -5 to 50 C
Depth…… 61 meters

Phycocyanin-Blue-green Algae (BGA-PC)
Sensor type..... Optical, fluorescence, with mechanical cleaning
Range..... Approximately 0 to 280,000 cells/mL of BGA (See **Principles of Operation** section for explanation of estimate); 0-100 Relative Fluorescence Units (RFU)
Accuracy..... No specification provided.
Linearity..... R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 400 ug/L
Detection Limit..... Approximately 220 cells/mL. Estimated from cultures of *Microcystis aeruginosa*
Resolution.....1 cell/mL; 0.1 RFU
Temperature Range -5 to 50 C
Depth…… 61 meters

Phycoerythrin-Blue-green Algae (BGA-PE)
Sensor type..... Optical, fluorescence, with mechanical cleaning
Range..... Approximately 0 to 200,000 cells/mL of BGA (See **Principles of Operation** section for explanation of estimate); 0-100 Relative Fluorescence Units (RFU)
Accuracy..... No specification provided.
Linearity..... R2 > 0.9999 for serial dilution of Rhodamine WT solution from 0 to 8 ug/L
Detection Limit..... Approximately 450 cells/mL. Estimated from cultures of a *Synechococcus* species.
Resolution.....1 cell/mL; 0.1 RFU

Temperature Range -5 to 50 C
Depth…… 61 meters

Rhodamine WT
Sensor type..... Optical, fluorescence, with mechanical cleaning
Range..... 0 to 200 µg/L Rhodamine WT
Accuracy..... +/- 5 % of the reading or 1 ug/L, whichever is greater
Resolution.....0.1 µg/L Rhodamine WT
Temperature Range -5 to 50C
Depth…… 61 meters

Conductivity*
Sensor Type.....4 electrode cell with autoranging
Range.....0 to 100 mS/cm
Accuracy.....+/- 0.5% of reading + 0.001 mS/cm
Resolution.....0.001 mS/cm to 0.1 mS/cm (range dependent)
Temperature Range -5 to 60 C
Depth……200 meters

Salinity
Sensor Type.....Calculated from conductivity and temperature
Range.....0 to 70 ppt
Accuracy.....+/- 1.0% of reading or 0.1 ppt, whichever is greater
Resolution.....0.01 ppt
Temperature Range -5 to 50 C
Depth……...200 meters

Nitrate-Nitrogen
Sensor Type.....Ion-selective electrode
Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……15 meters

Ammonium-Nitrogen
Sensor Type.....Ion-selective electrode
Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……15 meters

* Report outputs of specific conductance (conductivity corrected to 25 C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (Ed 1989).

Ammonia-Nitrogen
Sensor Type.....Calculated from ammonium, pH and temperature
Range.....0-200 mg/L-N
Accuracy.....+/- 10% of reading or 2 mg/L (whichever is greater)
Resolution.....0.001 mg/L-N to 1 mg/L-N (range dependent)
Temperature Range -5 to 50 C
Depth……15 meters

Chloride
Sensor Type.....Solid state ion-selective electrode
Range.....0-1000 mg/L
Accuracy.....+/- 15% of reading or 5 mg/L (whichever is greater)
Resolution.....0.001 mg/L to 1 mg/L (range dependent)
Temperature Range -5 to 50 C
Depth……15 meters

SOFTWARE SPECIFICATIONS

EcoWatch for Windows (included)

IBM PC compatible computer with CD ROM drive and with a 386 processor (or better) running Windows software. Compatible with Windows 3.1, Windows 95, Windows 98, Windows ME, Windows NT, Windows 2000, and Windows XP. Minimum RAM requirement: 4 megabytes

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Item # 069300
Drawing # A69300
Revision F
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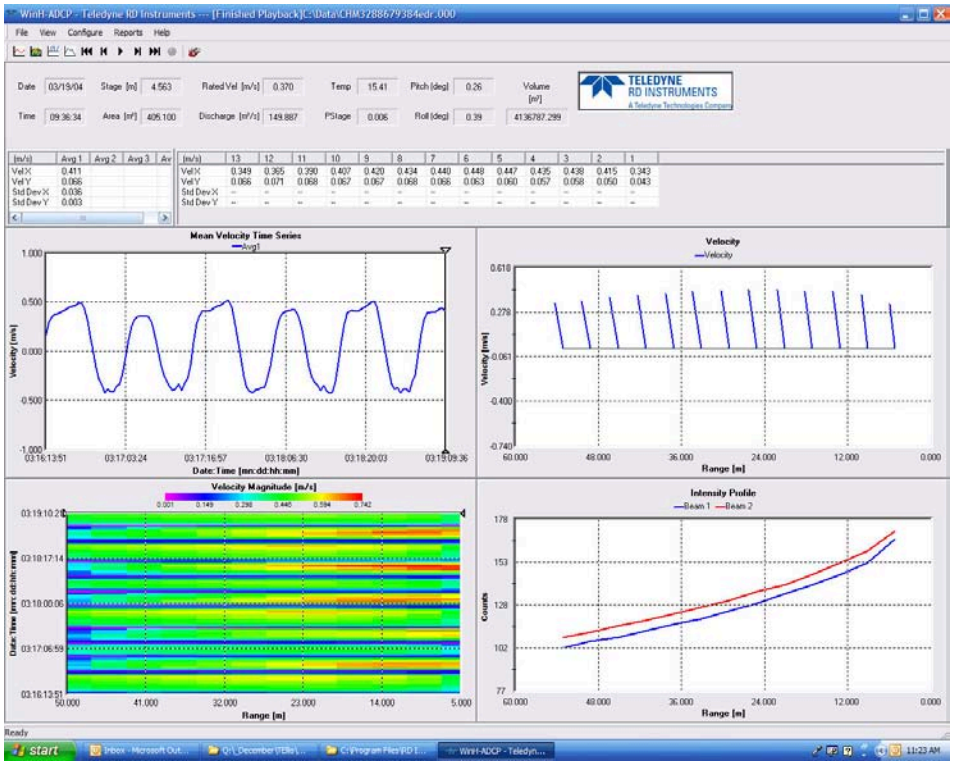
WinH-ADCP
User's Guide



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TELEDYNE
RD INSTRUMENTS
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WinH-ADCP User's Guide

1 Introduction

WinH-ADCP is Teledyne RD Instrument's real-time discharge data collection program for the Channel Master Horizontal ADCPs.

NOTE. This guide covers *WinH-ADCP* version 4.04 or higher.

1.1 System Requirements

WinH-ADCP requires the following:

- Windows XP® or Windows 2000®
- Pentium III 600 MHz class PC (higher recommended)
- 64 megabytes of RAM (128 MB RAM recommended)
- 50 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended)
- One Serial Port (two or more High Speed UART Serial Port recommended)
- Minimum display resolution of 1024 x 768, 256 color (higher recommended)
- CD-ROM Drive
- Mouse or other pointing device

1.2 Software Installation

To install *WinH-ADCP*, do the following.

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps “b” through “d.”

b. Click the **Start** button, and then click **Run**.

c. Type **<drive>:launch**. For example, if your CD-ROM drive is drive D, type **d:launch**.

d. Follow the browser instructions on your screen.

1.3 Conventions Used in this Guide

Conventions used in the *WinH-ADCP* User’s Guide have been established to help you learn how to use *WinH-ADCP* quickly and easily.

Windows menu items are printed in bold: **File** menu, **Open**. Items that need to be typed by the user or keys to press will be shown as <F1>. If a key combination were joined with a plus sign (<ALT+F>), you would press and hold the first key while you press the second key. Words printed in italics include program names (*WinH-ADCP*, *BBTalk*) and file names (*Test001r.000*).

Code or sample files are printed using a fixed font. Here is an example:

```
Horizontal ADCP
RD Instruments (c) 2008
All rights reserved.
Product Version: CMxx.x
```

You will find two other visual aids that help you: Notes and Cautions.

NOTE. This paragraph format indicates additional information that may help you avoid problems or that should be considered in using the described features.

CAUTION. This paragraph format warns the reader of hazardous procedures (for example, activities that may cause loss of data or damage to the H-ADCP).

2 File Naming Convention

There are several files associated with *WinH-ADCP* software. These files are:

- ***Data Files*** (*r.PD0, *r.0xx, **r.000, *r.P14*) – These files contain all data collected from the H-ADCP during data acquisition. For any specific deployment, these files contain the most information and are the largest. Refer to your ADCP's Technical Manual for a complete description of the format of raw data files. Data for this file type is collected through *WinH-ADCP*'s Data Acquisition mode. *WinH-ADCP*'s Data Playback/Processing mode accepts raw data files for display or processing.
- ***Average Files*** (**.AVG*) – These files contain calculated data for discharge created during acquisition or reprocessing.
- ***Report Files*** (**.RPT*) – These files contain the same data as average files, but in a more human readable format.
- ***Project Files*** (**.WSP*) – These files contain the discharge and averaging settings.

2.1 Data Files

These files are in RDI's standard ensemble format. All data files must contain horizontal ADCP ensembles in instrument or earth coordinates.

Ensembles from a Channel Master have fields for vertical beam data. *WinH-ADCP* gets the depth data from one of these fields. See the Channel Master Operation Manual for format details.

File Name Format: *ddddMMMx.000*

dddd	Filename prefix set in the **Real-Time Data Acquisition** screen (see Figure 15)
MMM	File number. This number starts at 000 and increments each time you stop and then start data collection. The maximum number is 999.
x	File type (assigned during data collection) r = Raw H-ADCP data
*r.PD0, *r.0xx, *r.000, *r.P14	File extension for data files.
Examples:	
NOAA001r.000	Deployment name = NOAA, file number = 001, data file, file extension = 000
Hadcp001r.PD0	Deployment name = Hadcp, file number = 001, data file, file extension = PD0

2.2 Average Files

Average files contain NMEA sentences. The National Marine Electronics Association defines the NMEA format in its NMEA 0183 publication. See http://www.nmea.org/pub/0183/index.html for more information. The NMEA 0183 standard provides for proprietary extensions. *WinH-ADCP* uses proprietary NMEA sentences in average files. These sentences conform to version 3.00 of the standard, dated July 1, 2000, except that they begin with identifiers other than $PRDI.

NOTE. *WinH-ADCP* does not generate NMEA checksums, and ignores them if present.

For example, a section of the file may look like this.

```
$ADCPH,IrishBayou_50cm_cell000r,0600,0.00,04/02/94 04:42:03.46,04/02/94
04:58:24.47,0.50,0050,0001,0010,0030,2.72,27.22,0.000,0.000,0.000,0.000,0.000,0.000
$$ADCPI,1,0,1,1.0,0.0,0.0,0.0,1.0,1,1,1,1,1,0,0,0
$HADCP,000002,04/02/94 04:42:08,-1.20,2.14,-0.56,0.68,-0.562,0.043,0.058,0.023,6.97,17.47,10.50
$HADCP,000003,04/02/94 04:42:12,-1.10,2.13,-0.51,0.68,-0.514,0.072,0.093,0.036,6.97,17.47,10.50
$HADCP,000004,04/02/94 04:42:17,-1.16,2.14,-0.54,0.68,-0.542,0.041,0.093,0.050,6.97,17.47,10.50
```

The first line in the file is a $ADCPH sentence, a header that summarizes parameters used in the calculations.

```
$ADCPH,c---c,X,x.x,c---c,c---c,x.x,X,X,X,X,X,X,x.x,x.x,x.x,x.x,x.x,x.x*hh<CR><LF>
```

Table 1: Average File Header Format

Field	Format	Description
1	c---c	Name of the data file with the ensemble data from which this discharge data was calculated.
2	X	HADCP frequency in KHz.
3	x.x	HADCP Mounting elevation in meters.
4	c---c	Date & time of first valid ensemble in data file in MM/DD/YY HH:MM:ss.ss format.
5	c---c	Date & time of last valid ensemble in data file in MM/DD/YY HH:MM:ss.ss format.
6	x.x	Cell length in meters.
7	X	Number of cells in the ensemble.
8	X	Time averaging interval in seconds.
9	X	Range average interval start cell.
10	X	Range average interval end cell.
11	X	Distance to the beginning of the range average interval start cell in meters.
12	X	Distance to the end of the range average interval end cell in meters.
13	x.x	a1 discharge coefficient.
14	x.x	a2 discharge coefficient.
15	x.x	a3 discharge coefficient.
16	x.x	b1 discharge coefficient.
17	x.x	b2 discharge coefficient.
18	x.x	b3 discharge coefficient.

The second line in the file is a $ADCPI sentence that summarizes the Index and Velocity command parameters used in the calculations.

```
$ADCPI,X,X,X,X.X,X.X,X.X,X.X,X.X,X,X,X,X,X,X,X,X
```

Table 2: Average File Index Data Format

Field	Format	Description
1	X	Internal Q Calculation Enabled
2	X	Internal Q Channel Geometry (0=cir,1=tra,2=rec,3=arb,4=rated)
3	X	Internal Q Bank (0=left,1=right)
4	X.X	Internal Q Transducer Elevation (0 to 5000m)
5	X.X	Internal Q Bottom Elevation (-100 to 5000m)
6	X.X	Internal Q Bottom Width (0 to 500 m)
7	X.X	Internal Q Side Slope (rise/run)
8	X.X	Internal Q Pipe Diameter
9	X	Internal Q Velocity Units (1 = m/s, 2 = ft/sec, 3 = cm/sec)
10	X	Internal Q Discharge Units (1 = m^3/s, 2 = ft^3/sec, 3 = l/sec, 4 = gal/min, 5 = million gal/day, 6 = million l/day)
11	X	Internal Q Volume Units (1 = m^3, 2 = ft^3, 3 = gal, 4 = acre-ft, 5 = liters, 6 = thousand gal, 6 = million gal)
12	X	Internal Q Area Units (1 = m^2, 2 = ft^2)
13	X	Internal Q Stage Units (1 = m, 2 = ft)
14	X	Internal Q Discharge Exp Units ((-6 to 6)
15	X	Internal Q Volume Exp Units ((-6 to 6)
16	X	Internal Q Output Data Format (0, 14, 19, 23)

Each remaining line is a $HADCP that summarizes discharge data from a single time averaging interval.

`$HADCP,X,c---c,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh<CR><LF>`

Table 3: Average File Discharge Data Format

Field	Format	Description
1	X	Ensemble number of the first valid data file ensemble in the averaging interval.
2	c---c	Date and time of the first ensemble in this time averaging interval in MM/DD/YY HH:MM:ss.ss format.
3	x.x	Discharge in m^3/s.
4	x.x	Cross section in m^2.
5	x.x	Index velocity magnitude in m^2. This is the time and range averaged velocity from the ensembles in this time averaging interval.
6	x.x	Stage in m.
7	x.x	Index velocity X or East component in m/s.
8	x.x	Index velocity Y or North component in m/s.
9	x.x	Index velocity X or East std dev in m/s.
10	x.x	Index velocity Y or North std dev in m/s.
11	x.x	Distance to the beginning of the first valid cell in the range average interval in meters.
12	x.x	Distance to the end of the last valid cell in the range average interval in meters.
13	x.x	Distance from beginning of the first valid cell to end of the last.

2.3 Report Files

Report files contain the same information as the Average file, but in a more easily readable formatted version. The file is a text file suitable for displaying with NotePad® or a word processor (see Figure 18).

NOTE. The Average file must be created first. The Report file will be created in the same directory as the Average file.

2.4 Workspace File

These files contain the discharge and averaging settings. Defaults will be used when *WinH-ADCP* is first opened.

NOTE. The workspace files are XML files and can be viewed by dragging it into Internet Explorer® or edited with NotePad®. However, TRDI strongly discourages this.

Save Workspace

To save a workspace file, on the **File** menu, click **Save Workspace As**. Enter the **file name** in the box and click **Save**.

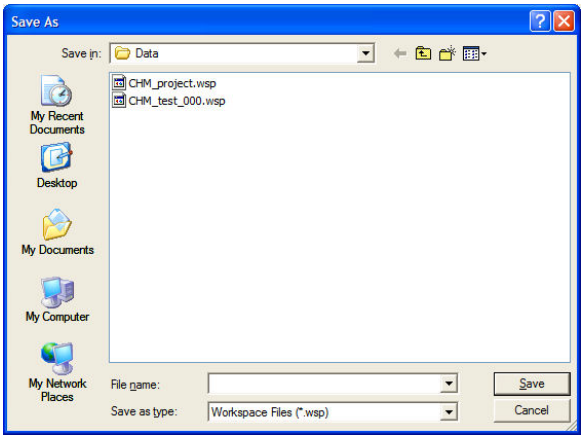


Figure 1. Save Workspace

Load Workspace

To load a workspace file, on the **File** menu, click **Load Workspace**. Select the file from the list and click **Open**.

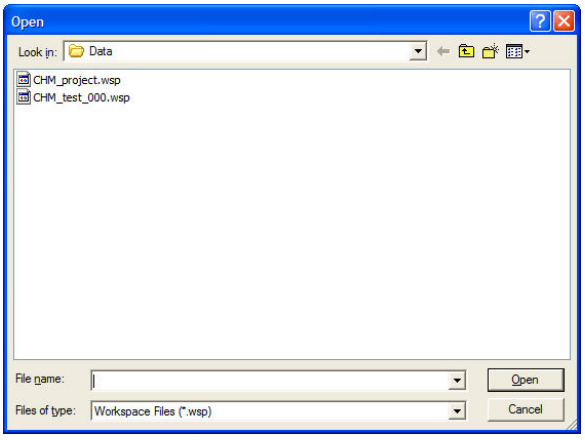


Figure 2. Load Workspace

3 Mount ADCP

WinH-ADCP can help with the physical mounting of an H-ADCP by causing it to ping and displaying real time orientation, depth, and temperature data in a large, easy to read font.

NOTE. Some H-ADCPs do not have a compass. For these, heading will not be displayed.

a. Start *WinH-ADCP*.

b. On the **Start** Screen, click **Mount ADCP**.

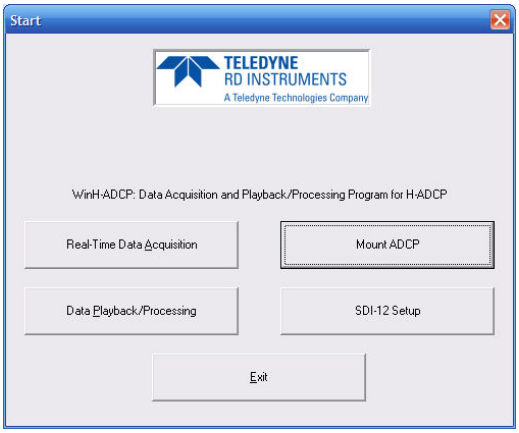


Figure 3. WinH-ADCP Start Screen

c. On the **Communications Settings** screen, enter the communications settings for the H-ADCP. If you are unsure of the setting, use the **Auto Detect** button.

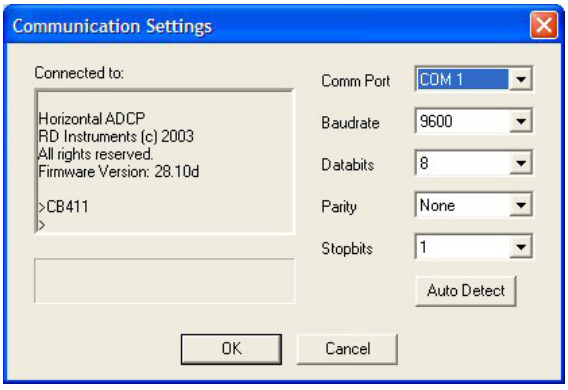


Figure 4. Communications Setting Screen

d. The Sensors screen of the *WinH-ADCP* software indicates the pitch and roll angles of the H-ADCP.

- Adjust the mount until the roll is zero. The H-ADCP rolls about the Y-axis. **The roll must be zero**.
- Adjust the mount until the pitch is zero. The H-ADCP pitches about the X-axis.

NOTE. A slight upward or downward pitch may be required to avoid beam interference from the bottom or surface).

e. Click **OK** to exit this screen.

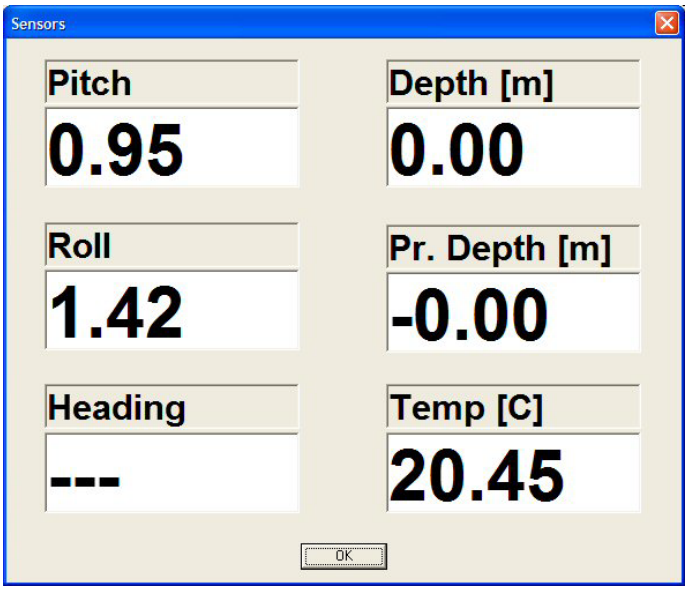


Figure 5. Sensors Screen

4 SDI-12 Communications

A Channel Master can communicate to a data logger using SDI-12 protocol. *WinH-ADCP* can help by configuring the Channel Master through its serial port, leaving it ready to respond to a data logger. *WinH-ADCP* does not use the SDI-12 protocol, and does not directly participate in SDI-12 data logging.

NOTE. SDI-12 Communications is only available for the Channel Master.

NOTE. For more information, see Application Note FSA-020 Channel Master SDI-12 Setup available for download on Teledyne RD Instruments' web site, Customer Service page (www.rdinstrument.com).

The basic measurement protocol of SDI-12 is:

a. The data logger sends a 0M! command to initiate measurement.

b. The Channel Master sends a message back saying how long the measurement will take (this is automatic and not seen by the user).

c. At the end of the measurement time, the data-logger sends a 0D0! command to read the data.

d. The Channel Master sends back four values; temperature, pressure, corrected pressure, and vertical beam range to surface.

e. To get the X component velocity data, the user must program the data-logger to then send a 0M1! command to request the X velocity component data. The Channel Master will immediately reply back with up to nine velocities from the first nine cells of the X velocity component profile data. The format of the data is the format required by the SDI-12 protocol definitions; the data logger reads and stores the data.

f. To get the Y component velocity data, the user must program the data-logger to then send a 0M2! command to request the Y velocity component data. The Channel Master will immediately reply back with up to nine velocities from the first nine cells of the Y velocity component profile data.

   If the data-logger supports concurrent SDI-12, then instead of the 0M... command, the data-logger must send 0C... commands and the Channel Master will respond with up to twenty X or Y velocities.

4.1 SDI-12 Setup

a. Connect and power up the Channel Master as shown in the Channel Master Operation Manual.

b. Start *WinH-ADCP*. If *WinH-ADCP* is already running, on the **Configure** menu, click **Use Wizard**. On the **Start Wizard**, click **SDI-12 Setup**.

c. On the **Communications Settings** dialog box, select the **COM Port**, **Baudrate**, **Databits**, and **Stopbits** that the H-ADCP is connected to. If you are unsure of the setting, use **Auto Detect**.

d. *WinH-ADCP* will connect to the H-ADCP and confirm the communication setting. On the **Connected to** box, you should see the H-ADCP wakeup message.

e. Click **OK** to continue to the **SDI-12 Configuration** screen.

f. Once the **SDI-12 Configuration** screen is setup, click **Start** to begin data collection.

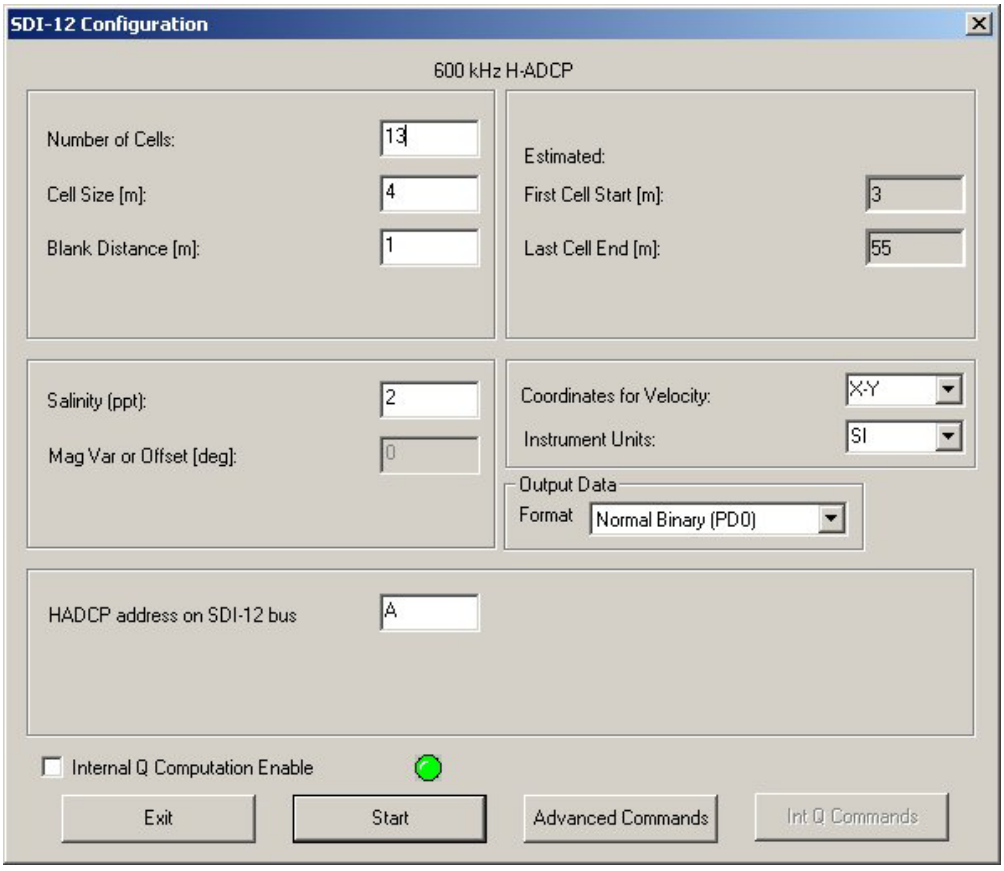


Figure 6. SDI-12 Configuration Screen

g. Disconnect the SDI-12 Serial Cable. Click **OK**.

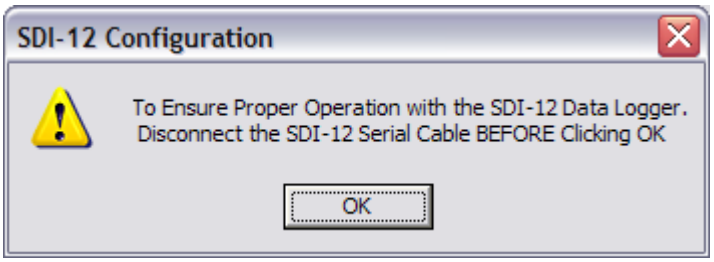


Figure 7. SDI-12 Message Box

h. You should see a message box confirming the Channel Master is configured and waiting for an SDI-12 data request (see Figure 8). Click **OK**.

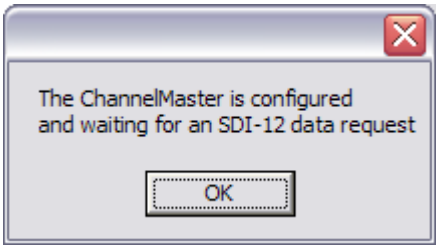


Figure 8. SDI-12 OK Message

SDI-12 Configuration Screen Settings

Number of Cells – Set the number of water profiling range cells (WN command) to cover the maximum expected range of the Channel Master.

Cell Size (m) –Sets the length for one cell measurement (WS command).

Blank Distance (m) – The blanking distance (WF command) should be set to 2 meters to maximize the Channel Master performance and minimize the unmeasured layer near the Channel Master.

NOTE. The Estimated **First Cell Distance** and **Last Cell Distance** are based on the **Number of Cells**, **Cell Size**, and **Blank Distance**.

Salinity (ppt) – Enter the salinity of the water. Freshwater is 0 ppt, saltwater is 35 ppt.

> **CAUTION.** It is critical to set the salinity (ES command) to the proper value. All of the velocities and distances measured by the ADCP are proportional to the speed of sound. If the salinity is set to the wrong value, it can produce an error in the calculated discharge.
>
> The discharge calculated using 35.0 ppt (ES35) is 8-10% higher than the discharge calculated using 0.0 ppt (ES0). If you obtain discharge values that are consistently too high by this margin, check the salinity setting in *WinH-ADCP*.

Magnetic Variation or Offset (deg) – Use a chart to determine the local magnetic variation in your area. If there is an eastern variation in your area, the output of the ADCP's magnetic compass when pointed to true North will read less than 360°. If the local variation is to the West, the magnetic compass will read greater than 0° if pointed to true North. East variations are positive (entered as 12.5°) and West variations are negative (entered as -12.5 °).

> **NOTE. Magnetic Variation** is only used when Earth Coordinates are selected.

Coordinates for Velocity – Select **Instrument** or **Earth Coordinates**.

Units – Sets *WinH-ADCP* to either **SI** or **English** units.

> **NOTE.** Only SI units are supported in version 3.1.

HADCP address on SDI-12 Bus – Use A to Z or 0 to 9 as valid addresses.

Select the **Internal Q Computation Enable** box and then click the **Int Q Commands** button to generate the appropriate Index Velocity and Discharge Commands and send them to the Channel Master when it is started (see Internal Q Computation).

> **CAUTION.** The Channel Master must have the latest firmware in order to use the Index Velocity and Discharge Commands. If not, an error will be generated because the "I" commands are not included in the old firmware.

Advanced Commands – Use this button to go to the **Advanced Commands** screen (see Advanced Commands).

5 H-ADCP Setup for Data Collection

The following sections have an in-depth explanation of the steps necessary to setup the H-ADCP to collect data for discharge measurements using an index method. The H-ADCP collects depth and velocity data. It is important to choose the cells and averaging parameters carefully to get the best discharge measurements. *WinH-ADCP* helps with the setup by configuring the H-ADCP with different cell and timing parameters. Real-time data is collected, stored on the hard disk, and displayed.

Data is averaged with up to four different sets of averaging parameters at the same time and used to calculate discharges. The different averages can be displayed together on the same graph. The averaged data is also stored on disk in a separate file.

5.1 Communications Setup

When *WinH-ADCP* is first started in the Data Acquisition mode, you must set up the communications with the H-ADCP.

NOTE. Once setup, *WinH-ADCP* will remember the settings and use them each time the program is started.

a. Connect and power up the H-ADCP as shown in the ADCP Technical Manual.

b. Start *WinH-ADCP*. If *WinH-ADCP* is already running, on the **Configure** menu, click **Use Wizard**. On the **Start Wizard**, click **Real-Time Data Acquisition**.

c. On the **Communications Settings** dialog box, select the **COM Port**, **Baudrate**, **Databits**, and **Stopbits** that the H-ADCP is connected to. If you are unsure of the setting, use **Auto Detect**.

d. *WinH-ADCP* will connect to the H-ADCP and confirm the communication setting. On the **Connected to** box, you should see the H-ADCP wakeup message.

e. Click **OK** to continue to the **Real-Time Data Acquisition** screen.

f. Once the **Real-Time Data Acquisition** screen is setup (see Real-Time Data Acquisition Screen), click the **Save Project** button to save the discharge and averaging settings.

g. Click **Start** to begin data collection.

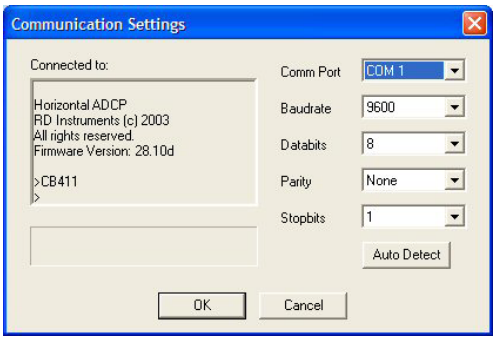


Figure 9. Communications Settings

5.2 Real-Time Data Acquisition Screen

WinH-ADCP uses the inputs in the **Real-Time Data Acquisition** screen to set the profiling parameters sent to the H-ADCP. In the following, we will describe each parameter and give guidelines for setting these commands for acquiring reliable discharge data.

NOTE. Refer to the H-ADCP Operation Manual for more detailed information about each command.

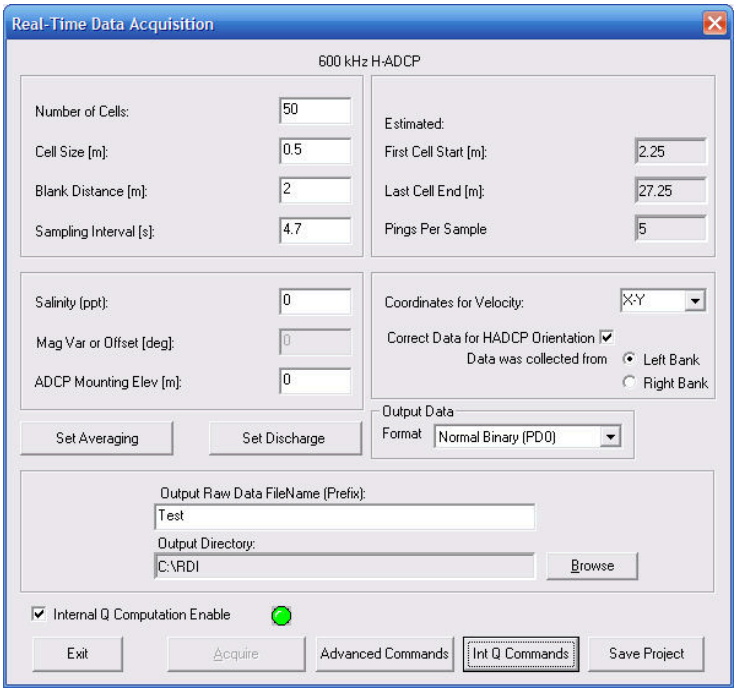


Figure 10. Real-Time Data Acquisition Screen

NOTE. The default settings are based on the H-ADCP frequency.

Real-Time Data Acquisition Setup Screen Settings

Number of Cells – Set the number of water profiling range cells (WN command) to cover the maximum expected range of the H-ADCP.

Cell Size (m) –Sets the length for one cell measurement (WS command).

Blank Distance (m) – The blanking distance (WF command) should be set to 2 meters to maximize the H-ADCP performance and minimize the un-measured layer near the H-ADCP.

NOTE. The Estimated **First Cell Distance** and **Last Cell Distance** are based on the **Number of Cells**, **Cell Size**, and **Blank Distance**.

Sampling Interval (s) – By default, the H-ADCP pings every 0.5 seconds. All pings in the sampling period are time averaged before being recorded. Set the time average interval to control how much data is averaged together.

Salinity (ppt) – Enter the salinity of the water. Freshwater is 0 ppt, saltwater is 35 ppt.

CAUTION. It is critical to set the salinity (ES command) to the proper value. All of the velocities and distances measured by the ADCP are proportional to the speed of sound. If the salinity is set to the wrong value, it can produce an error in the calculated discharge.

The discharge calculated using 35.0 ppt (ES35) is 8-10% higher than the discharge calculated using 0.0 ppt (ES0). If you obtain discharge values that are consistently too high by this margin, check the salinity setting in *WinH-ADCP*.

Magnetic Variation or Offset (deg) – Use a chart to determine the local magnetic variation in your area. If there is an eastern variation in your area, the output of the ADCP's magnetic compass when pointed to true North will read less than 360°. If the local variation is to the West, the magnetic compass will read greater than 0° if pointed to true North. East variations are positive (entered as 12.5°) and West variations are negative (entered as -12.5°).

NOTE. Magnetic Variation is only used when Earth Coordinates are selected.

ADCP Mounting Elevation – Set the elevation of the ADCP transducer faces above a local datum. This value is used by the ADCP to calculate the water surface level (stage).

Coordinates for Velocity – Select **Instrument (X-Y)** or **Earth Coordinates**.

NOTE. Only Instrument (X-Y) units are supported in version 3.1.

Correct Data for HADCP Orientation – *WinH-ADCP* can correct displays so that data appears as if viewed from above the river with downstream toward the top of the monitor. Positive X is downstream, positive Y is toward the right bank. For corrected profile graphs and text windows, data is oriented so that the left bank is on the left and cell 1 is plotted on the left side of the graph.

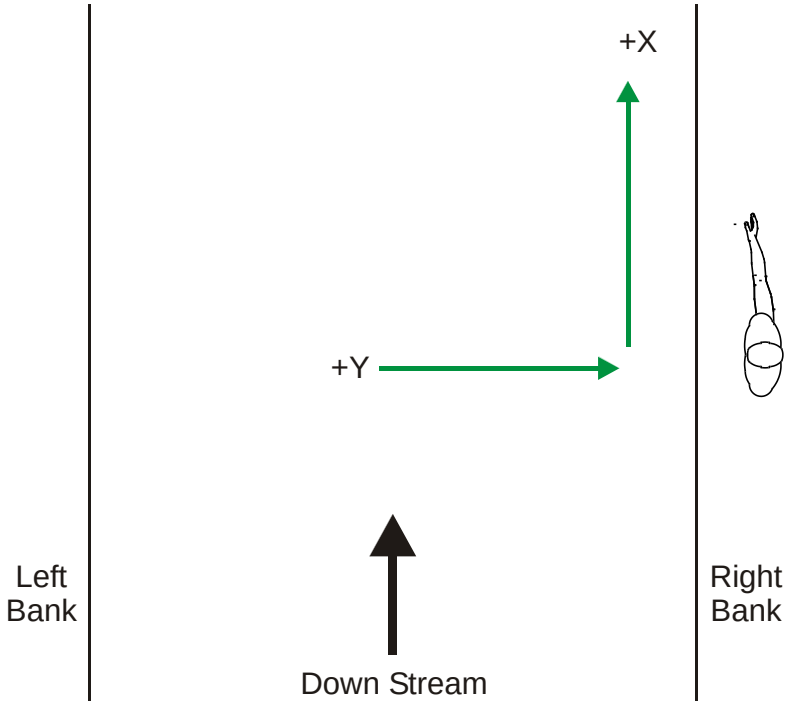


Figure 11. Data Corrected for Display

When facing downstream on a river, the bank on the left is the left bank, and the bank on the right is the right bank.

Instrument coordinates for an H-ADCP oriented for normal river data acquisition are Positive X to the right when facing the opposite bank, Positive Y toward the opposite bank, and Positive Z up.

If data is collected in Instrument Coordinates with the H-ADCP on the left bank, the signs of the X and Y components will be reversed.

Displaying Data in Instrument Coordinates. If the H-ADCP is on the left bank, the X components of velocities are negative. Negative discharges would be calculated from this. This is different from the same data col-

lected from the right bank. Profile data collected from the left bank would also appear inverted. To correct the displays, use the **Correct Data for HADCP Orientation** function.

If the **Correct Data for HADCP Orientation** is disabled, no changes are made to the signs of data or the orientation of graph or text axes.

If the **Correct Data for HADCP Orientation** is enabled, then the **Left**/**Right** bank option determines which bank the data came from.

Table 4: Correct Data for HADCP Orientation

Data	Correction
X velocity Discharge	For left bank, invert the sign.
Y velocity	For right bank, invert the sign.
Range axis	For right bank, invert the axis to put cell 1 (nearest the right bank) on the right.

NOTE. Data is corrected for the display only, not in the data file.

NOTE. No corrections are applied to Earth coordinate data.

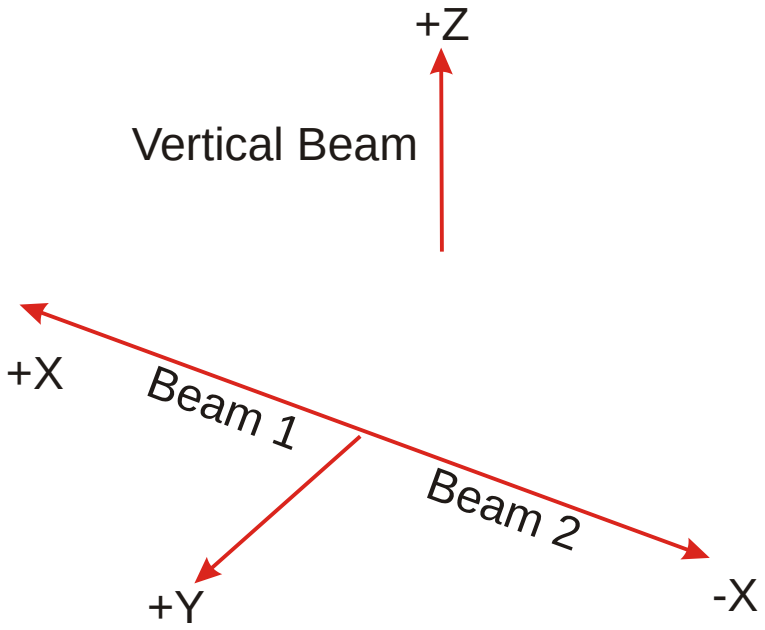


Figure 12. Instruments Coordinates

Set Averaging – Averaging parameters depend on **Number of Cells**, **Cell Size**, **Blank Distance**, and **Sampling Interval**. Changing any of these settings causes changes to the averaging parameters. After any change, click the **Set Averaging** button to confirm the new averaging parameters (see Averaging).

Set Discharge – Click this button to set the Discharge Coefficients (see Discharge Calculation and Coefficients).

Output Data – Select the output data format from the drop down list.

Output Raw Data File (Prefix) – *WinH-ADCP* uses the **Output Raw Data File (Prefix)** to create the raw data file made during data collection. For example, if the prefix is set to **Test**, than the data file will be named *Test000r.PD0* (see File Naming Convention).

Output Directory – Use the **Output Directory** field to select where the raw data file will be stored.

Select the **Internal Q Computation Enable** box and then click the **Int Q Commands** button to generate the appropriate Index Velocity and Discharge Commands and send them to the Channel Master when it is started (see Internal Q Computation).

NOTE. Index Velocity and Discharge Commands are only available for the Channel Master.

CAUTION. The Channel Master must have the latest firmware in order to use the Index Velocity and Discharge Commands. If not, an error will be generated because the "I" commands are not included in the old firmware.

Advanced Commands – Use this button to go to the **Advanced Commands** screen (see Advanced Commands).

Save Project – Click the **Save Project** button to save the discharge and averaging settings (see Workspace File).

5.3 H-ADCP Commands

The commands shown in Table 5 explain each command set by *WinH-ADCP*. To view what commands are being sent to the H-ADCP, click the **Advanced Commands** button on the **Real-Time Data Acquisition** screen (see Figure 10). These commands directly affect the range of the H-ADCP, standard deviation (accuracy) of the data, and power usage. Table 5 explains the commands used in the sample command file for a 300 kHz H-ADCP using the default settings.

Table 5: Commands Created By WinH-ADCP

HADCP Setup Screen	Command	Choices	Description
N/A	CR1	Sets factory defaults	This is the first command sent to the H-ADCP to place it in a "known" state.
Number of Cells	WN50	Number of range cells	Number of range cell (bin)s is set to the value from **Number of Cells**.
Cell Size	WS400	Range cell size	Range cell (bin) size is set to the value from **Cell Size**.
Blank Distance	WF200	Blank after transmit	Moves the location of the first range cell away from the transducer head from the value set in the **Blank Distance**.
Sampling Interval	WP8	Number of pings	Value is calculated by *WinH-ADCP*.
N/A	TP00:00.60	Time between pings	*WinH-ADCP* always sets this to 0.5 seconds for 1200 and 600kHz ADCPs and 0.6 seconds for 300kHz ADCPs.
Sampling Interval	TE00:00:01.00	Time per ensemble	Ensemble or sample interval is set from the **Sampling Interval**.
Coordinates for Velocity	EX01010	Coordinate transformations	Selects **Instruments** or **Earth** coordinates
N/A	EZ1111101	Sensor source	Calculate speed of sound from readings, use pressure sensor, internal compass, internal tilt sensor, and transducer temperature sensor.
Salinity	ES0	Salinity	Salinity of water is set to the value from **Salinity**.
Mag Var/Offset	EB00000	Heading bias	Set to the **Magnetic Variation** value (command used for Earth coordinates only).
N/A	CF11110	Flow control	Sends the data out the H-ADCP serial interface.
N/A	CS	Start pinging	Last command sent to begin collecting data.

5.4 Advanced Commands

You can directly control the profiling parameters sent to the H-ADCP using the **Additional Commands** box. The H-ADCP Operation Manual explains all direct commands in detail. The **Current Commands** box lets you view the direct commands that will always be sent to the H-ADCP.

CAUTION. The current commands are sent before any additional commands. Sending an **Additional Command** can OVERRIDE the **Current Commands**.

When the Data Acquisition mode is first started, the commands in the **Current Commands** box are sent by *WinH-ADCP* to the H-ADCP to set its profiling parameters. The **Additional Commands** are sent next and can ***override*** the **Current Commands**.

NOTE. Some values for the **Current Commands** are based on information entered in the **Real-Time Data Acquisition** screen (see Figure 10). Adjust any command setting on the **Real-Time Data Acquisition** Setup screen rather than adding an additional command to override the command setting.

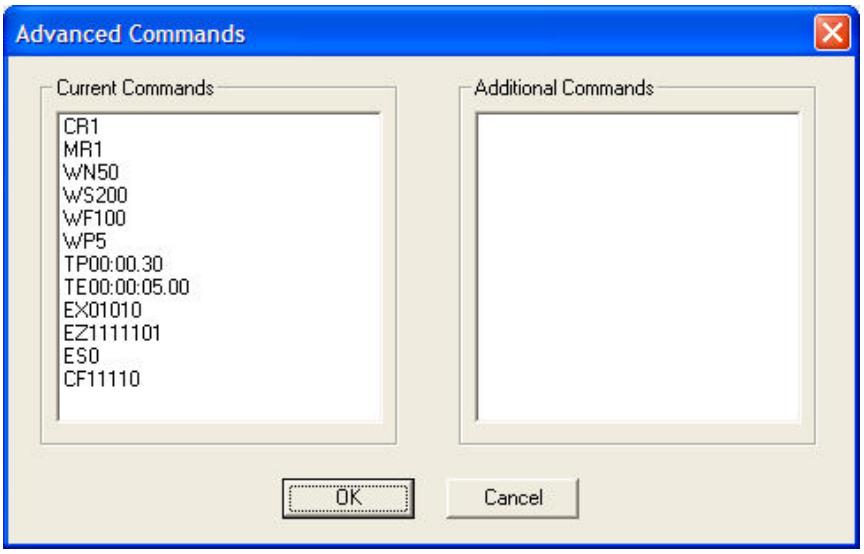


Figure 13. Advanced Commands

NOTE. See Table 5 for a description of the **Current Commands**.

6 Data Playback

After data is collected and stored on disk, *WinH-ADCP* can play it back. If desired, averaging and discharge parameters can be changed. A desirable part of a file can be examined more closely in playback than during data collection. Controls are available to step through a file.

a. Start *WinH-ADCP* by double clicking the *WinH-ADCP* icon, or if the program is already running go to the **Configure** menu and click **Use Wizard**.

b. On the **Start Wizard**, click **Data Playback/Processing**.

c. On the **Open ADCP Raw Data File** screen select the file to be played and click the **Open** button.

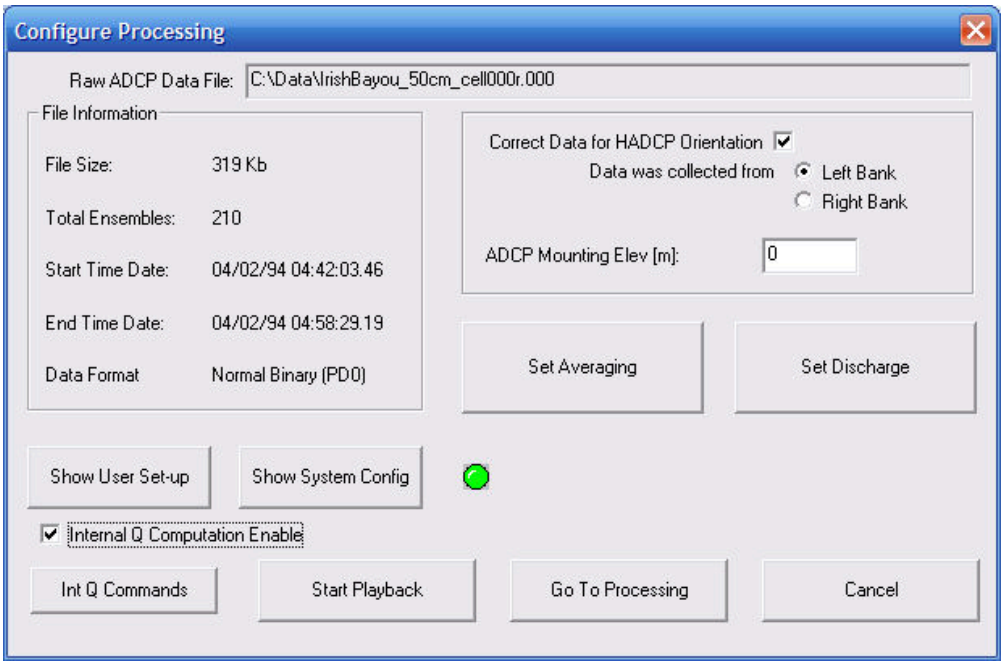


Figure 14. Configure Processing Screen

d. Check the **Correct Data for HADCP Orientation** box and select where the data was collected (**Left** or **Right Bank**) or leave it unchecked to view uncorrected data.

e. Enter the **ADCP Mounting Elevation**.

NOTE. To see information about the raw data file, click **Show User Setup** and **Show System Configuration**.

f. Click the **Set Averaging** button to set averaging (see Averaging). Click **OK** to return to the **Configure Processing** screen.

g. Click the **Set Discharge** button. On the Discharge screen, enter the **Area** and **Velocity Coefficients** (see Discharge Calculation and Coefficients). Click **OK** to return to the **Configure Processing** screen.

> **NOTE.** The averaging and discharge coefficients must be set properly or the discharge measurements will be meaningless.

h. Select the **Internal Q Computation Enable** box and then click the **Int Q Commands** button to have *WinHADCP* compute discharge using the channel geometry descriptions (see Internal Q Computation).

i. To begin data playback, click **Start Playback**.

7 Data Processing

Data can also be reprocessed. This causes a new average file to be generated using the new averaging and discharge parameters. Otherwise, it is much like playback.

a. Start *WinH-ADCP* by double clicking the *WinH-ADCP* icon, or if the program is already running go to the **Configure** menu and click **Use Wizard**.

b. On the Start Wizard, click Data Playback/Processing.

c. On the **Open ADCP Raw Data File** screen select the file to be played and click the **Open** button.

d. Check the **Correct Data for HADCP Orientation** box and select where the data was collected (**Left** or **Right Bank**) (see Figure 11).

e. Enter the **ADCP Mounting Elevation**.

> **NOTE.** To see information about the raw data file, click **Show User Setup** and **Show System Configuration**.

f. Click the **Set Averaging** button. On the **Average 1 Setup** screen, enter the **Averaging Interval** and/or **Range Averaging** cells. Click **OK** to return to the **Configure Processing** screen (see Averaging).

g. Click the **Set Discharge** button. On the Discharge screen, enter the **Area** and **Velocity Coefficients**. Click **OK** to return to the **Configure Processing** screen (see Discharge Calculation and Coefficients).

> **NOTE.** The averaging and discharge coefficients must be set properly or the discharge measurements will be meaningless.

h. On the **Configure Processing** screen, click the **Go to Processing** Button. Enter a **Data File (Prefix)** and select the folder where the processed data file will be stored.

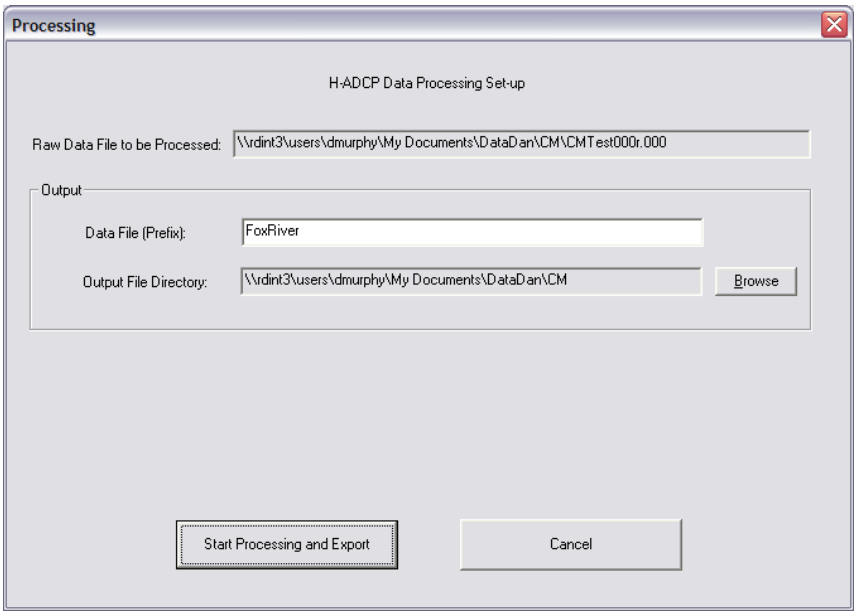


Figure 15. Processing Screen

Processing Screen Settings

- *WinH-ADCP* uses the **Data File (Prefix)** to create the processed data file made during data processing.
- Use the **Output File Directory** field to select where the processed data file will be stored.

i. To begin processing data, click **Start Processing and Export**.

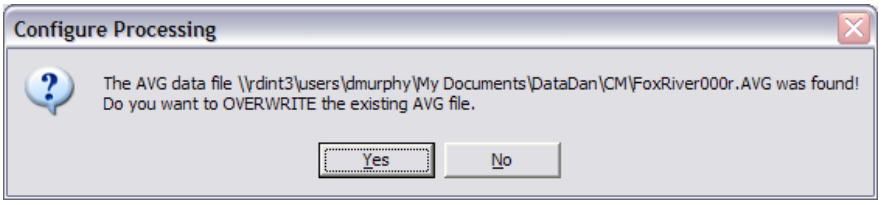


Figure 16. Configure Processing Warning Message

j. If the Average file already exists, you will be prompted if you want to over write the file. Selecting **No** will return you to the **Processing** screen. Select a different **Data File Prefix** or **Output File Directory**.

7.1 Output Text Report Files

Report files contain the same data as average files, but in a human readable format. Like the average file, the content of the report file depends on averaging and discharge parameters. A report file can be generated after data acquisition has been stopped or during playback. It will use the current averaging and discharge parameters.

a. On the **Reports** menu, click **Output Text Report File**. Click **OK** on the message box. The Report file will be created in the same directory as the Average file.

Figure 17. Output Text Report File

b. To view the report file, open it with any text editor (i.e. NotePad®).

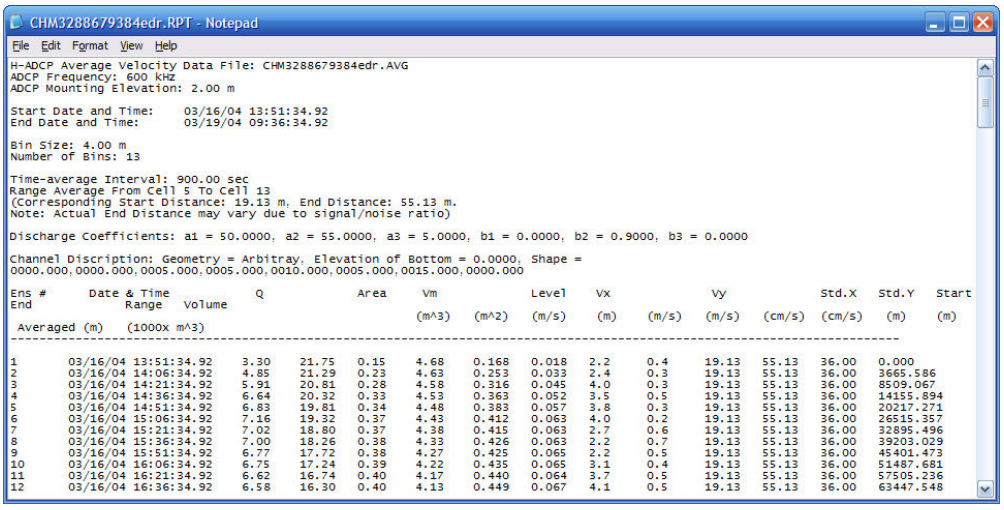


Figure 18. Report File

8 Tools Menu

The **Tools** menu provides several functions for the Channel Master's recorder, and functions for setting the accumulated volume to zero and setting the clock.

8.1 Recover Data

The loop recorder contains approximately two megabytes of solid-state nonvolatile memory, which can be used to continuously record data. If more data is collected than fits in the memory, the oldest data will be overwritten with the newest data. You always have up to the last two megabytes of data available for download.

To recover internally logged data click **Recover CM Recorder** on the **Tools** menu. Select the folder where to save the data file. Click **OK**.

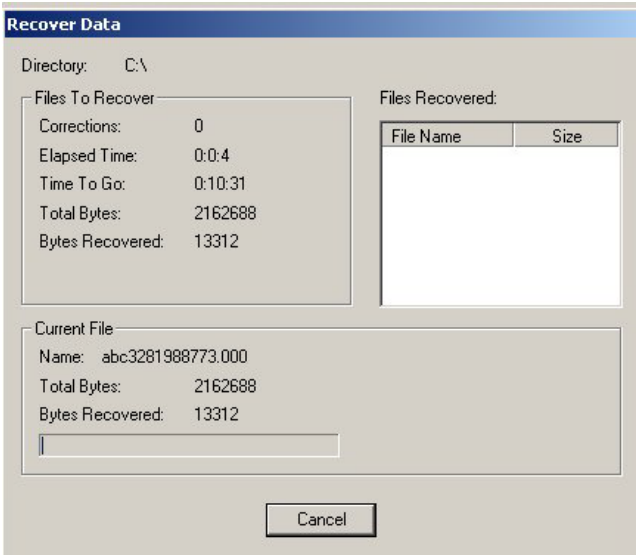


Figure 19. Recover Data Screen

8.2 Erase Data

To erase all internally logged data click **Erase CM Recorder** on the **Tools** menu. When selected, a dialog will appear to verify that you want to erase the internal recorder. Select **Yes** to continue. At the **Erase Channel Master Data File Status** screen, click **OK**.

8.3 Set the File Name

To set the file name for internally logged data click **Set CM Filename** on the **Tools** menu. Enter the file name on the **Channel Master Internal File** screen. Click **OK** to continue.

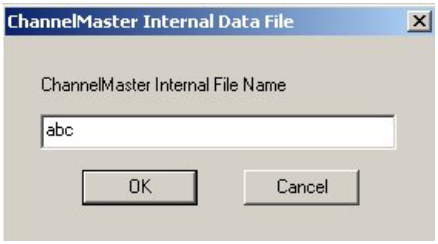


Figure 20. Set the Channel Master File Name

8.4 Zero Channel Master Volume

To set the Channel Master internal accumulated volume to zero, click **Volume Reset** on the **Tools** Menu. Select **Yes**, **No**, or **Cancel** to continue. A message box will display when the volume is successfully set to zero. Click **OK** to continue.

8.5 Set Channel Master Clock

To set the Channel Master clock, click **Set CM Clock** on the **Tools** Menu. Select either synchronizing the Channel Master's clock to the computer clock or manually selecting a date and time.

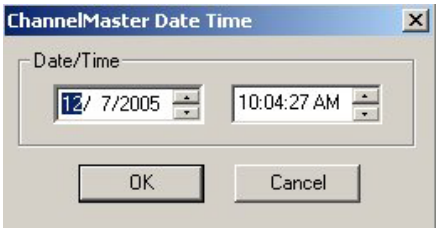


Figure 21. Set Channel Master Clock

9 Averaging

For data collection, *WinH-ADCP* configures the H-ADCP to ping every 0.5 second. The H-ADCP accumulates the data internally until a sampling interval elapses. The data is then time averaged and sent out the H-ADCP's serial port in RDI's standard ensemble format. *WinH-ADCP* collects this data and stores it in a *r.000 data file. For *WinH-ADCP*, the important information in each ensemble is depth and velocity from a series of cells at regularly spaced intervals.

WinH-ADCP does further time averaging on all ensembles within a time averaging interval. Then the time averaged velocities from all the cells between selected start and end ranges are averaged into a single velocity. This time and range averaged velocity is the index velocity used to calculate discharge. One to four sets of time and range averaging intervals may be enabled. The Contour, Velocity Current Stick, and Profile graphs always show Average 1. The Time Series graph shows Average 1 and any other averages the user selects.

It is important to determine proper time-averaging interval and range-averaging interval for the Index-Velocity (see Discharge Calculation and Coefficients). Below is a general guidance on determining time and range averaging interval.

9.1 The Time-Averaging Interval

The time averaging interval should be long enough to average out measurement uncertainties due to random noise in the H-ADCP and turbulence in the water. In most cases, turbulence will be dominant. We recommend the time averaging standards for traditional current meter velocity measurement in national hydrological codes or regulations.

WinH-ADCP provides an estimate of the standard deviation expected in the velocity measurements due to random noise in the H-ADCP. A value is provided for a single time averaged cell velocity, and for the time and range averaged velocity. Since the data file contains one ensemble per sampling interval, all time averaging intervals must be a multiple of the file's sampling interval.

9.2 The Range-Averaging Interval

One of the prime purposes of *WinH-ADCP* is to help determine the best cells to use for the index velocity. This is often done by measuring as much data as possible under different conditions and finding which cells give the best results by trial and error. For example, group Cell 1 through Cell 20 together or group Cell 10 to Cell 30 together. The range-averaging interval

should be determined so that the corresponding Index-velocity has the best correlation with the channel mean velocity at the site.

9.3 Average Setup

The **Average Setup** dialog pops up when the **Set Average** button is clicked during setup for either Real-Time Data Acquisition (see Figure 10) or Data Playback/Processing (see Figure 14). In either case, Average one is always enabled and Averages two through four are optional.

NOTE. The averaging parameters can only be changed after stopping and then restarting Acquisition/Playback.

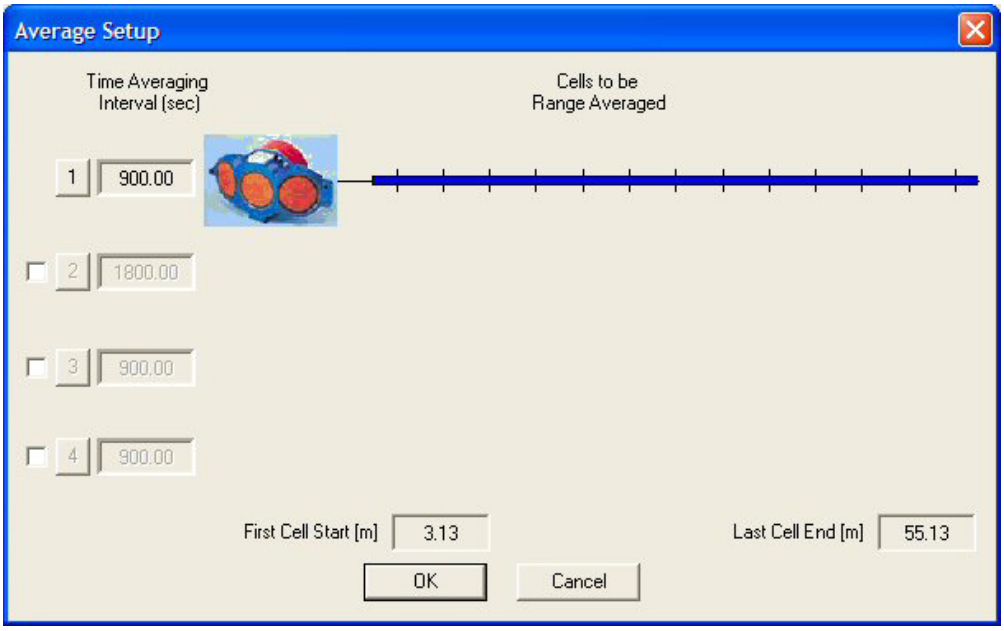


Figure 22. Average Setup

c. Enable averages by checking the boxes on the left of the dialog. A diagram of selected cells will appear for each checked box. It will show selected cells with a colored bar if averaging parameters are valid.

d. To edit averaging parameters, click the **1** button. A dialog will pop up (see Figure 23) that allows time and range averaging intervals to be set. Enter the **Time Averaging Interval** and/or **Range Averaging Start** and **End** cells.

e. Click **OK** to return to the **Average Setup** screen.

f. To set average intervals 2 through 4, check the box next to the number to enable the average and click the numbered box to set the average. You can have up to four averaging intervals.

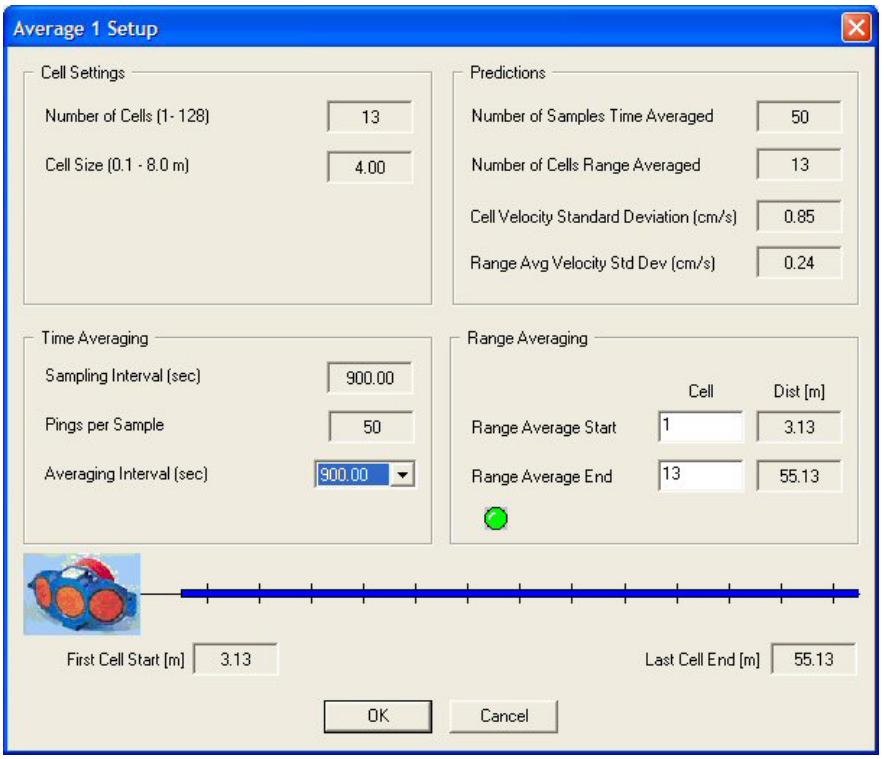


Figure 23. Time Averaging

NOTE. Average one is always displayed. If Averages two through four are enabled in setup, they can be displayed or hidden on the Time Series graph during Acquisition/Playback (see WinH-ADCP Displays).

10 Discharge Calculation and Coefficients

WinH-ADCP employs an Index-Velocity Method (see References) to calculate discharge using the velocity and stage data collected by the H-ADCP.

The area and velocity coefficients are site-specific and must be determined from field survey and regression analysis by the user or by a contractor of the user. It is user's responsibility to obtain the site-specific coefficients to assure the discharge calculations are correct and accurate.

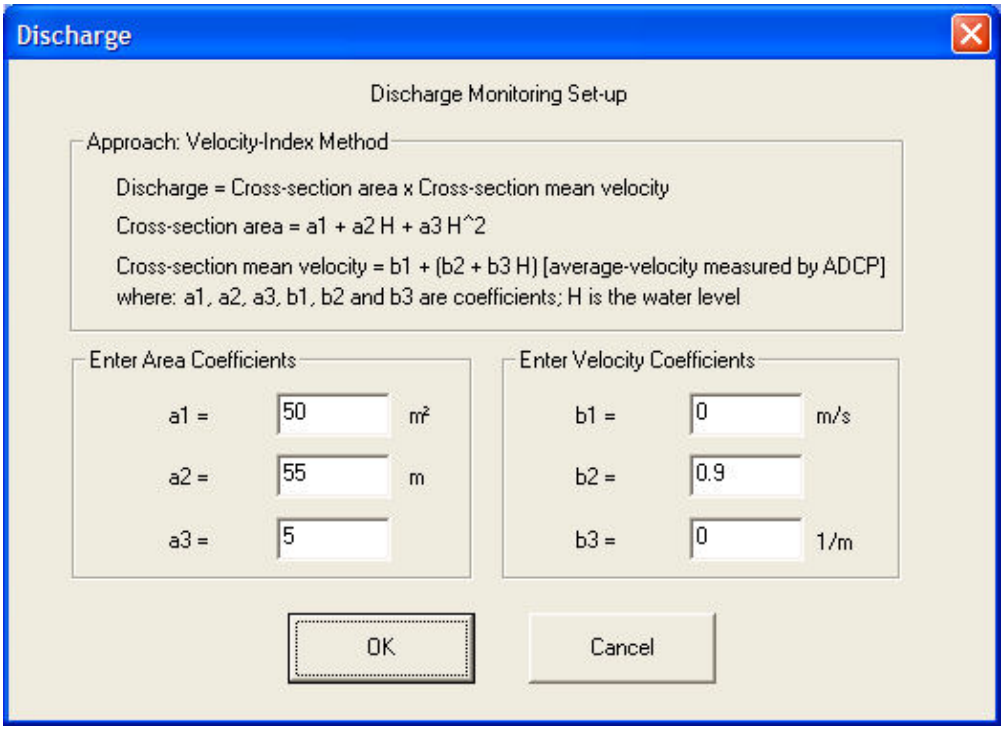


Figure 24. Discharge Coefficients

A general formula for calculating discharge Q is as follows:

$$Q = AV \qquad (1)$$

Where

A = cross-section area,

V = mean velocity of the channel.

The cross-section area depends on cross-section geometry and stage. For a specific site, the cross-section area is a function of stage only:

$$A = f(H) \qquad (2)$$

Where

H =stage in m

A = depth as measured by the ADCP + mounting elevation

WinH-ADCP employs the following second order polynomial function for area and stage regression (Rantz, 1982):

$$A = a_1 + a_2 H + a_3 H^2 \quad (3)$$

Where

a_1, a_2, a_3 = site specific area regression coefficients

According to the Index-velocity method, the mean velocity V can be expressed as a function of an Index-Velocity as follows (see References).

$$V = b_1 + (b_2 + b_3 H)V_I \quad (4)$$

Where

V_I = Index-Velocity in *m/s*. In our case, it is a time and range averaged velocity component in X direction (i.e., the direction parallel to the channel main flow), measured by the H-ADCP;

b_1, b_2, b_3 = site specific velocity regression coefficients.

In the case where stage change is not significant, the above equation may be reduced to:

$$V = b_1 + b_2 V_I \quad (5)$$

That is, the mean velocity is a function of the Index-Velocity only.

11 Internal Q Computation

Select the **Internal Q Computation Enable** box and then click the **Int Q Commands** button to setup the Index Velocity and Discharge Commands.

Using the Internal Q commands will setup the Channel Master to compute discharge internally and to have *WinHADCP* compute discharge using the channel geometry descriptions.

NOTE. Index Velocity and Discharge Commands are only available for the Channel Master.

CAUTION. If the **Internal Q Computation Enable** box is selected, the Channel Master will send Index Velocity and Discharge Commands ("I" commands). Your Channel Master must have Product Version CM02.03 or above or the "I" commands will generate an error when sent to the Channel Master.

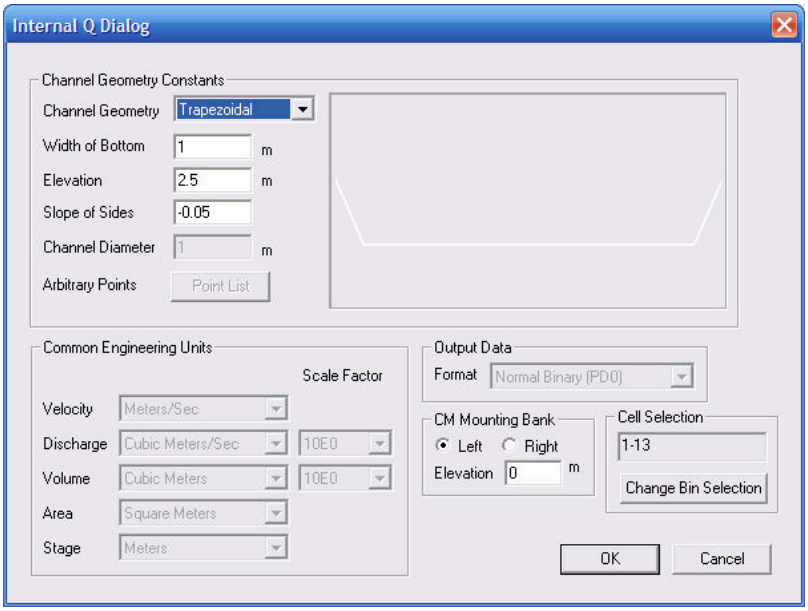


Figure 25. Internal Q Dialog Screen

Channel Geometry Constants

Select the **Channel Geometry** (**Circular**, **Trapezoidal**, **Rectangular**, **Arbitrary**, or **Rated**). This value will determine the value set for the IC command. Depending on the value set for the channel geometry, a graphic representation of the channel geometry will display along with input boxes to enter the geometry parameters as follows:

Trapezoidal

- **Width of Bottom**.
- **Elevation** of the channel.
- **Slope of Sides** – slope is computed as rise/run. Adjust the slope of the graphic to indicate the slope that is input.

Rectangular

- **Width of Bottom**.
- **Elevation** of Bottom.

Circular

- **Diameter**.
- **Elevation** of bottom.

Rated

- **Elevation** of bottom.

Arbitrary

Click the **Point List** button and use the **Arbitrary Shape Dialog** screen to enter the total number of pairs to be input. Use the **Insert** button to add a row or the **Delete** button to remove a row. Click **OK** when all points have been entered.

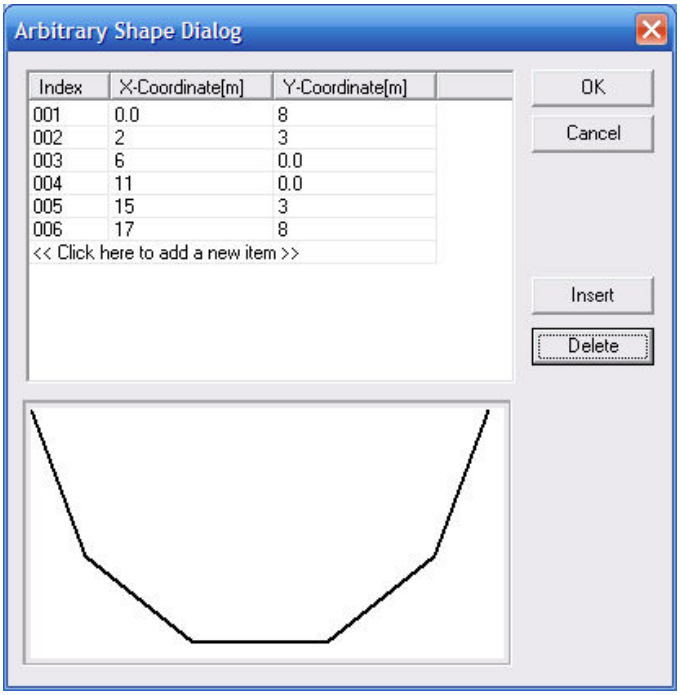


Figure 26. Arbitrary Shape Dialog Screen

Up to 99 *n*, *x*, *y* coordinate pairs define the shape of the channel where *n* is the **Index** for the coordinate, *x* is the horizontal distance, and *y* is the elevation of the bottom at that distance (see Figure 27).

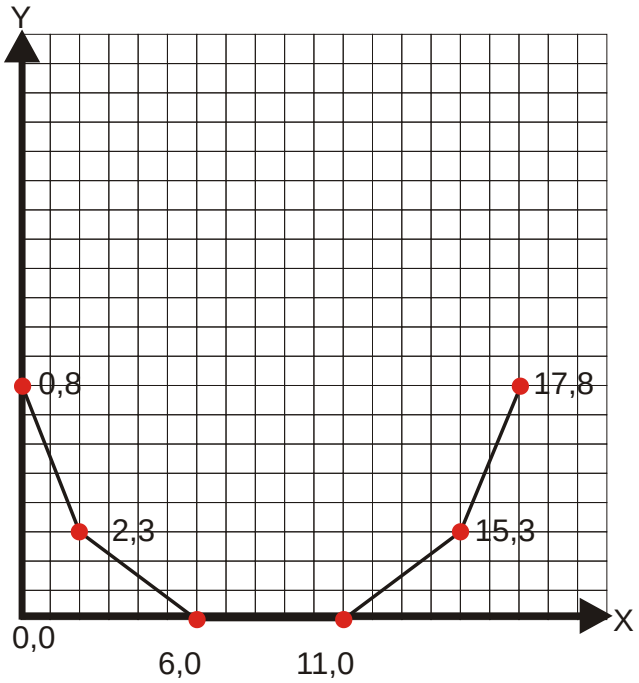


Figure 27. Example Channel Arbitrary Points

Output Data Format: Select the Output Data Format from the drop down list box.

- **Normal binary (PD0)** – this will set PD0 in the commands sent to the Channel Master.
- **Special binary (PD14)** – this will set PD14 in the commands sent to the Channel Master.
- **Discharge summary (PD19)** – this will set PD19 in the commands sent to the Channel Master.
- **Discharge summary (PD23)** – this will set PD23 in the commands sent to the Channel Master.

NOTE. When PD19 or PD23 is selected, no data will display on the screen. PD19 and PD23 are a NMEA output data string to send a summary of flow, stage, volume, etc. to a data logger, RTU, or other serial ASCII device.

CM Mounting Bank: Select either the **Left** or **Right** button. This sets the value of the IB command.

Elevation: Select the Channel Master's mounting elevation.

Cells Selection: Use the **Cell Selection** box to select the cells to be used to compute the index velocity. Click the **Change Bin Selection** button to enter either a range of cells to be average, i.e. cells 3-14, or a list of cells to be averaged, i.e. cells 2, 3, 4, 7, 8, 9, 13.

Common Engineering Units

NOTE. The Common Engineering Units can only be changed when collecting data in Real-Time. The fields are grayed out in Playback mode.

Velocity Units:

- Meters per second
- Feet per second -
- Centimeters per second

Discharge: Select a **Scale Factor** between 10^{-0} to 10^{6}

- Cubic meters per second
- Cubic feet per second
- Liters per second
- Gallons per minute
- Million gallons per day
- Million liters per day

Volume: Select a **Scale Factor** for the first four selections to 10^{-0} to 10^{6}.

- Cubic meters
- Cubic ft
- Gallons
- Liters
- Acre-ft
- Thousand gallons
- Million gallons

Area:

- Square meters
- Square feet

Stage:

- Meters
- Feet

12 WinH-ADCP Displays

The following displays are available during both Data Acquisition and Data Playback/Processing modes.

The top section of the display shows the discharge information. This data is meaningless if the averaging and discharge coefficients have not been set (see Averaging and Discharge Calculation and Coefficients).

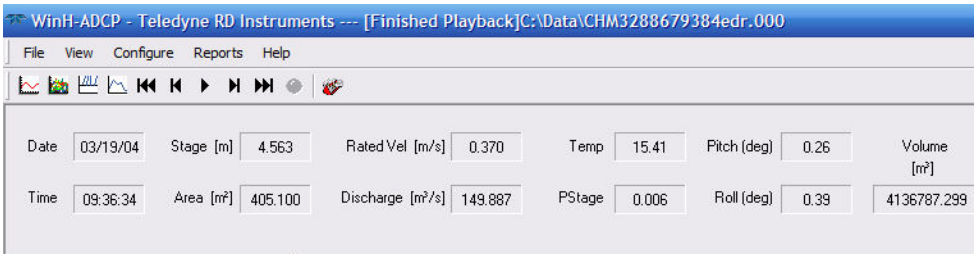


Figure 28. Main Display – Discharge Information

12.1 User Configuration

On the **View** menu, select **User Configuration** to view information about how the H-ADCP was setup when the data was collected. You can also access this information by selecting **Show User Setup** on the **Configure Processing** screen (see Figure 14).

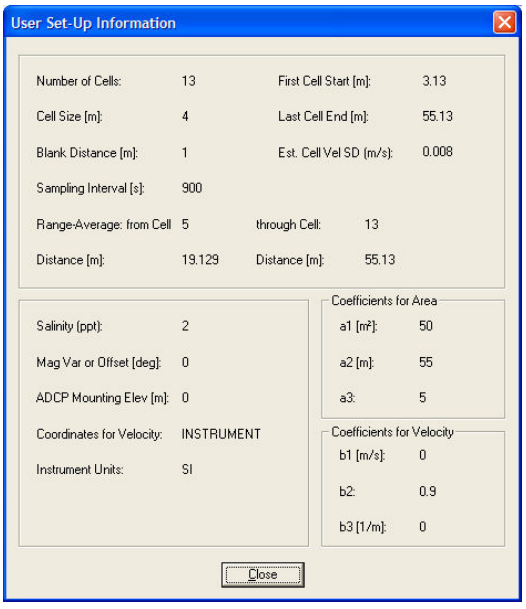


Figure 29. User Configuration

12.2 Hardware Configuration

On the **View** menu, select **Hardware Configuration** to view information about the type of H-ADCP that was used when the data was collected. You can also access this information by selecting **Show System Configuration** on the **Configure Processing** screen (see Figure 14).

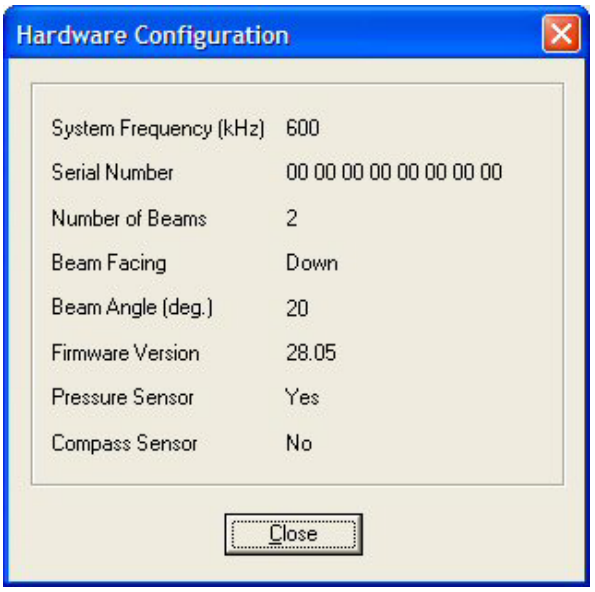


Figure 30. Hardware Configuration

12.3 Customizing Charts

The scaling options for the graphics screens can be modified. By selecting the appropriate minimum and maximum values for the displays, specific features in the data become more visible.

NOTE. To quickly access the graph scales right-click on the graph and select Properties.

12.3.1 Time Series Window

On the **View**, **Time Series** menu, you have a several choices of viewing the data (see Figure 31).

NOTE. The ruler may be dragged along the graph to step through the data in playback mode.

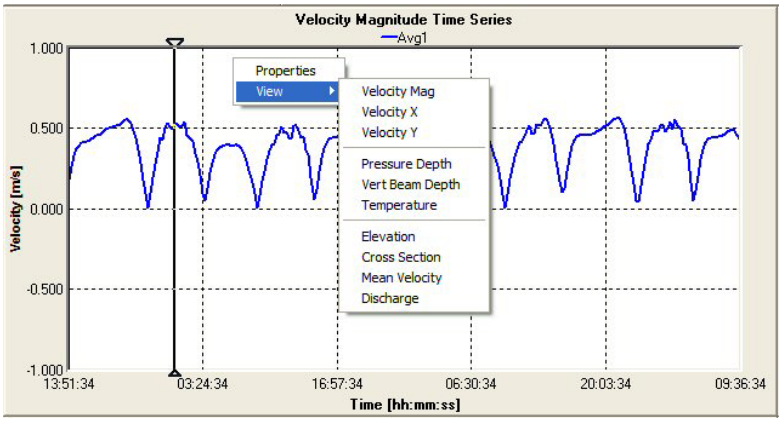


Figure 31. Time Series Display

On the **Configure** menu, click **Time Series Window** or right-click on the graph and select **Properties**. Adjust the settings as needed.

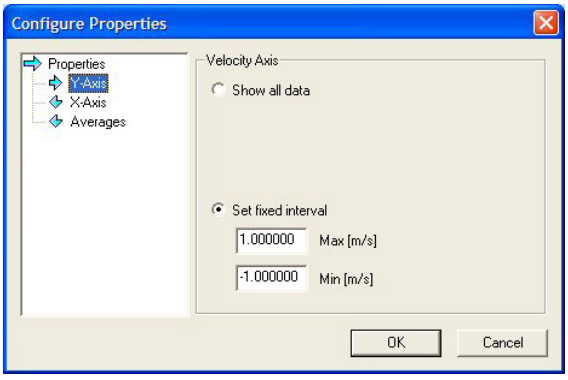


Figure 32. Customizing the Time Series Window – Y-Axis

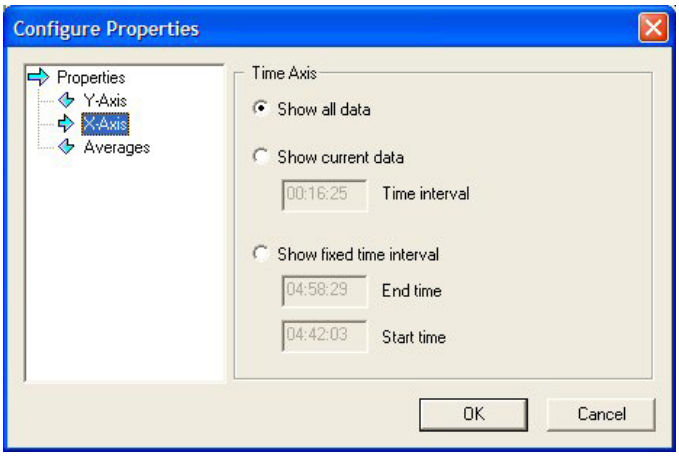


Figure 33. Customizing the Time Series Window – X-Axis

Show all data sets the axis to show all data read so far. If a new type of data is chosen from the view menu, the axis will be adjusted.

Show current data (time axis only) shows the most recent data. The user sets a time interval to set how much data is displayed.

Set fixed interval sets the axis to values set by the user. The axis is not adjusted when new data types are selected.

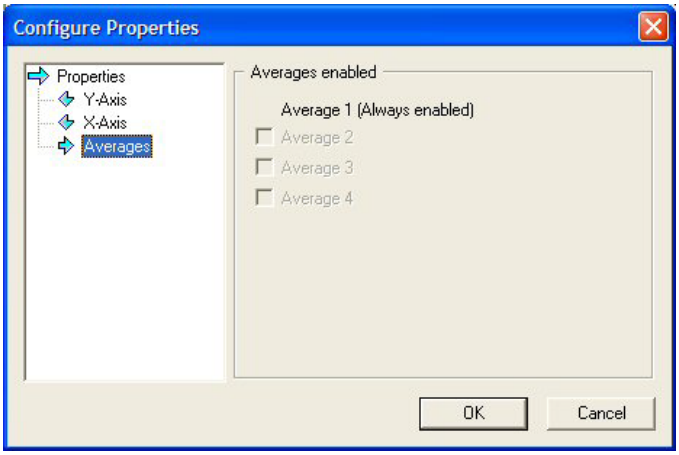


Figure 34. Customizing the Time Series Window – Averages

Averages displays or hides data averaged with different parameters. Only enabled averages may be displayed.

12.3.2 Contour Window

On the **View**, **Color Contour** menu, you have a choice of viewing the **Velocity X**, **Velocity Y**, or the **Velocity Magnitude** data. The **Contour** window displays the Average 1 setup only.

NOTE. The pointer may be dragged along the graph to step through the data.

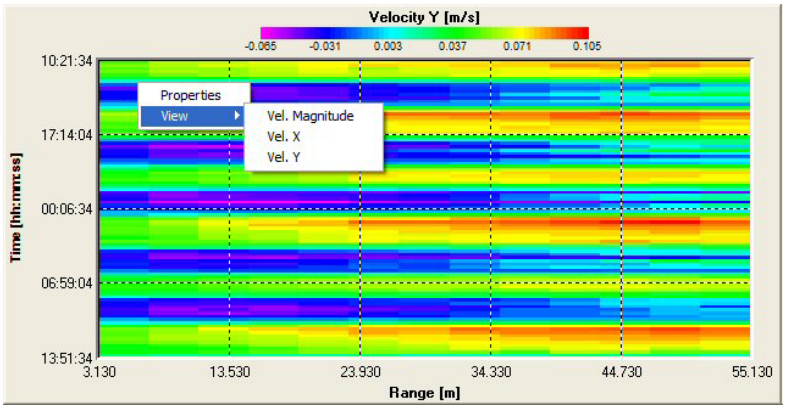


Figure 35. Contour Graph

On the **Configure** menu, click **Contour Window**. Adjust the settings as needed.

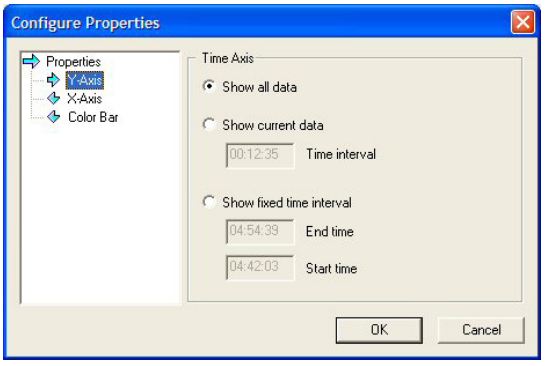


Figure 36. Customizing the Contour Window – Y-Axis

Show all data sets the axis to show all data read so far. If a new type of data is chosen from the view menu, the axis will be adjusted.

Show current data (time axis only) shows the most recent data. The user sets a time interval to set how much data is displayed.

Set fixed interval sets the axis to values set by the user. The axis is not adjusted when new data types are selected.

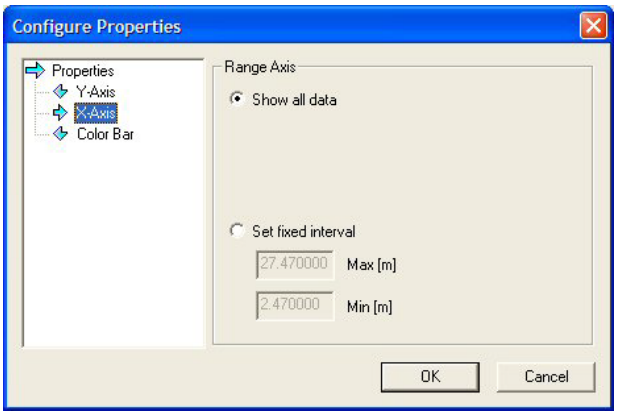


Figure 37. Customizing the Contour Window – X-Axis

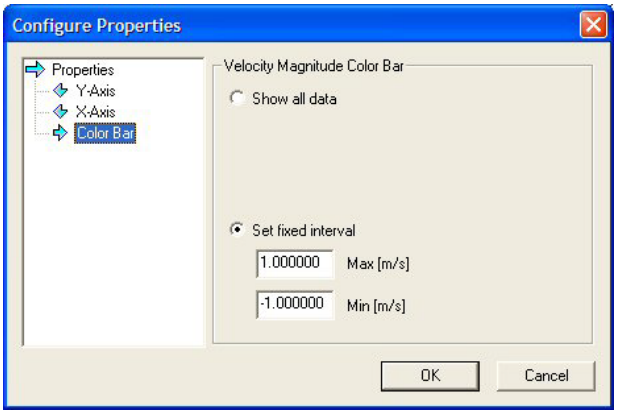


Figure 38. Customizing the Contour Window – Color Bar

Show all data sets the axis to show all data read so far. If a new type of data is chosen from the view menu, the axis will be adjusted.

Set fixed interval sets the axis to values set by the user. The axis is not adjusted when new data types are selected.

12.3.3 Velocity Current Stick Window

The **Velocity Current Stick** window displays velocity as "sticks". The **Velocity Current Stick** window displays the Average 1 setup only. If the velocity shows as negative flow, stop and check the **Correct Data for HADCP Orientation** box (see Figure 10 or Figure 14) and select the proper bank that the data was collected from (**Left** or **Right Bank**).

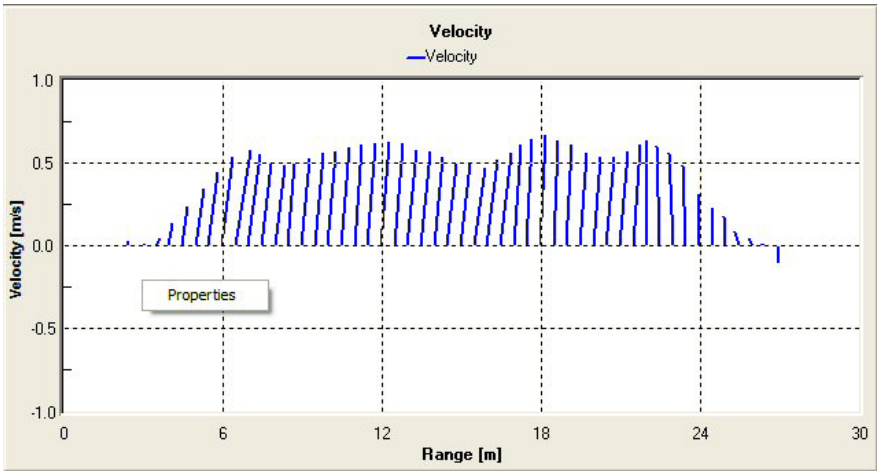


Figure 39. Current Stick Window

On the **Configure** menu, click **Current Stick**. Adjust the settings as needed.

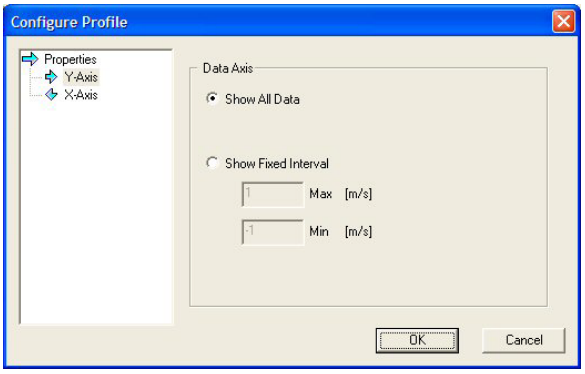


Figure 40. Customizing the Current Stick Window – Y-Axis

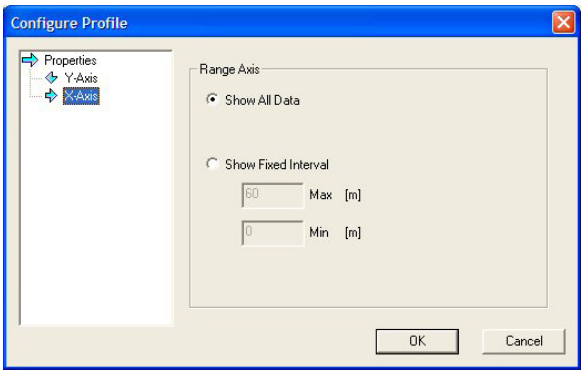


Figure 41. Customizing the Current Stick Window – X-Axis

12.3.4 Profile Window

On the **View**, **Profile** menu, you have a choice of viewing the **Velocity**, **Standard Deviation**, **Intensity**, or **Correlation** data. The **Profile** window displays the Average 1 setup only.

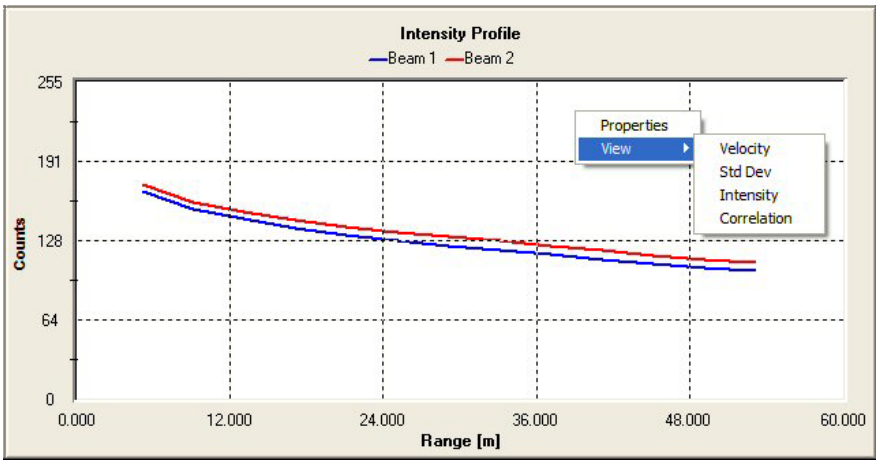


Figure 42. Intensity Profile Graph

On the **Configure** menu, click **Profile**. Adjust the settings as needed.

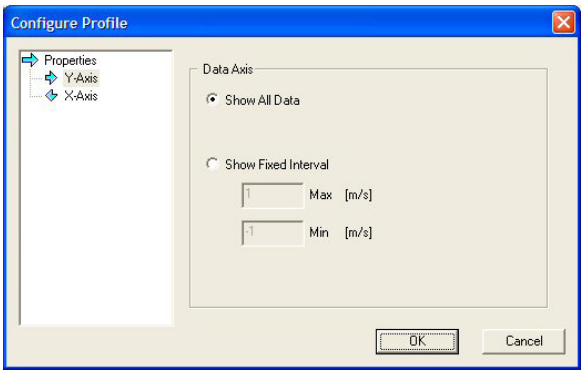


Figure 43. Customizing the Intensity Profile Window – Y-Axis

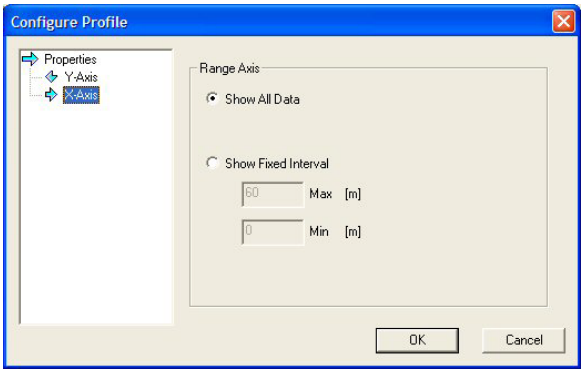


Figure 44. Customizing the Intensity Profile Window – X-Axis

13 References

Rantz, S. E. (1982). “Measurement and comparison of streamflow: volume 1. Measurement of stage and discharge”. United States Geological Survey, Water-Supply paper 2175.

Rantz, S. E. (1982). “Measurement and comparison of streamflow: volume 2. Computation of discharge”. United States Geological Water-Supply paper 2175.

14 Software History

Version 4.04 (17 December 2008)

- Fixed issues on the Chinese machines with creation of output directory
- Added Help File Vista compatibility
- Time Series now defaults to “Show all data” initially
- Added PD14 capability back in
- Real-Time Acquire now works with Chinese Characters

Version 4.03 (17 September 2008)

- Fixed the error message that appeared when an averaging file is not found (IDS_AVG_FILE_NOT_FOUND_EX)
- Enabling the menu items that were showing “??”
- Fixed the processing dialog
- Allowed users to also specify PD23 output in all of the places where they can currently select PD19.
- Fixed the problem with vertical beam data not being decoded correctly and causing multiple wraparounds on longer ranges.

Version 4.02 (27 June 2008)

- WinHADCP is now compatible with currently released versions of WinRiver II, WavesMon and DVS.
- Fixed the shrinking of the windows every time the program is opened.
- If the directory to which “Output Text Report File” is pointing doesn’t exist – it is created, instead of showing a false “success” message.

Version 4.01 (03 February 2006)

- In SDI Configuration removed IO0-command from the command list when “Internal Q" calculations are disabled.
- Fixed left bank velocities correction in AVG file.
- Added CK-command to be sent just before CS-command.
- Fixed discharge units scaling.
- Disabled ability to select PD19 format when “Internal Q” calculations disabled.

Version 4.00 (15 December 2005):

- Added capability to set the Channel Master internal accumulated volume to zero.
- Added capability to set Channel Master clock.
- Added capability to recover data stored in the Channel Master internal recorder.
- Added capability to erase data stored in the Channel Master internal recorder.
- Added capability to set the file name in the Channel Master internal recorder.
- Added capability to decode and display PD14 formatted data in real-time and playback.
- Added capability to decode, display and graph pitch and roll data in real-time or playback.
- Added user interface for setting up Channel Master and WinH-ADCP to compute discharge using new channel geometry descriptions.
- Added capability to compute discharge using new channel geometry descriptions.

Version 3.02 (24 June 2005):

- Fixed the problem with playing back some data files.

Version 3.01 (7 January 2005)

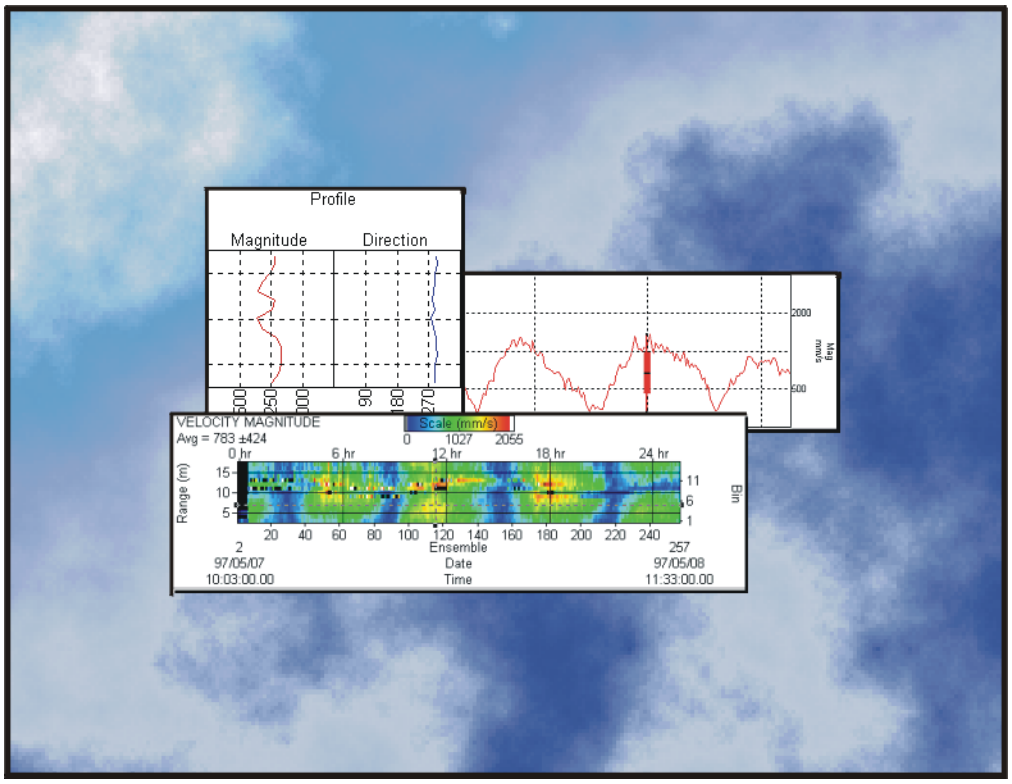
- Updated File Info window.
- Added tabular windows displaying velocity and standard deviation information.
- Added horizontal profile graph windows.
- Updated time series and contour graph windows.
- Added capability to do four averages.
- Updated wizard.
- Added SDI-12 configuration feature.
- Added Mount ADCP feature.
- Added Help menu item and help file.

Version 2.23 (October 31, 2003)

- Initial release.

NOTES

WinADCP User's Guide



P/N 957-6158-00 (January 2001)

RD Instruments

Acoustic Doppler Solutions

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WinADCP User's Guide

1 Introduction

This guide is an overview on using the *WinADCP* software provided with your system.

NOTE. This guide covers version 1.10 or earlier.

1.1 System Requirements

WinADCP requires the following:

- Windows 95®, Windows 98®, or Windows NT 4.0® with Service Pack 4 installed
- Pentium class PC 233 MHz (350 MHz or higher recommended)
- 32 megabytes of RAM (64 MB RAM recommended)
- 6 MB Free Disk Space plus space for data files (A large, fast hard disk is recommended)
- One Serial Port (two or more High Speed UART Serial Port recommended)
- Minimum display resolution of 800 x 600, 256 color (1024 x 768 recommended)
- CD-ROM Drive
- Mouse or other pointing device

1.2 Software Installation

To install the software, do the following.

a. Insert the compact disc into your CD-ROM drive and then follow the browser instructions on your screen. If the browser does not appear, complete Steps "b" through "d."

b. Click the **Start** button, and then click **Run**.

c. Type **<drive>:launch**. For example, if your CD-ROM drive is drive D, type **d:launch**.

d. Follow the browser instructions on your screen.

Once, installed, you will have a shortcut added to your Windows® **Start** menu. The **Winadcp** shortcut will start *WinADCP*.

NOTE. The default directory for WinADCP installation is C:\program files\RD Instruments\Winadcp.

2 Using WinADCP

WinADCP is a software package for use with RDI Acoustic Doppler Current Profilers. This software package supports both the Narrowband and the Broadband/Workhorse Binary Output Data Formats.

In general, *WinADCP* gives the user a visual sense of the entire set of data. It also allows the user to zoom in on a portion of the data for closer analysis.

2.1 Opening Data Files

You can open BroadBand, NarrowBand, or WorkHorse raw binary data files. Binary data files that have segmented consecutive file names (i.e. DEMO001r.000, DEMO001r.001, DEMO001r.002) will be read in as one file if **MultiFile** is enabled on the **File** menu.

a. On the **File** menu, check that **MultiFile** is checked. Click **Open**.

b. Select the data file to be opened.

c. Click **Open**.

2.2 Whole Set

WinADCP has two main graphic display forms. The form located in the upper right portion of the screen is called the **Whole Set**. The form located across the bottom half of the display is called the **Sub Set**. Each of these forms displays a portion of the entire data set as a color contour. In addition

to the color contour, **Sub Set** displays the user selected **Profile**, **Series**, and **Ancillary** data.

The **Whole Set** form is displayed in the upper right-hand portion of *WinADCP*. When a file containing a Binary Output Data Format is opened, the entire set of the selected data type is displayed as a color contour located within the **Whole Set** form.

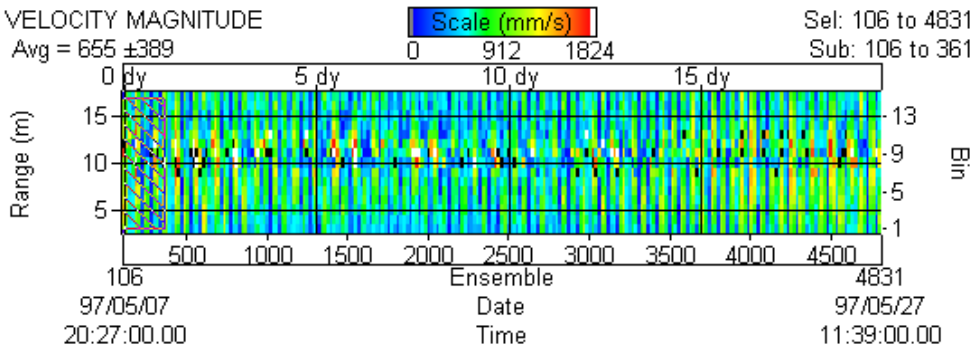


Figure 1. Whole Set

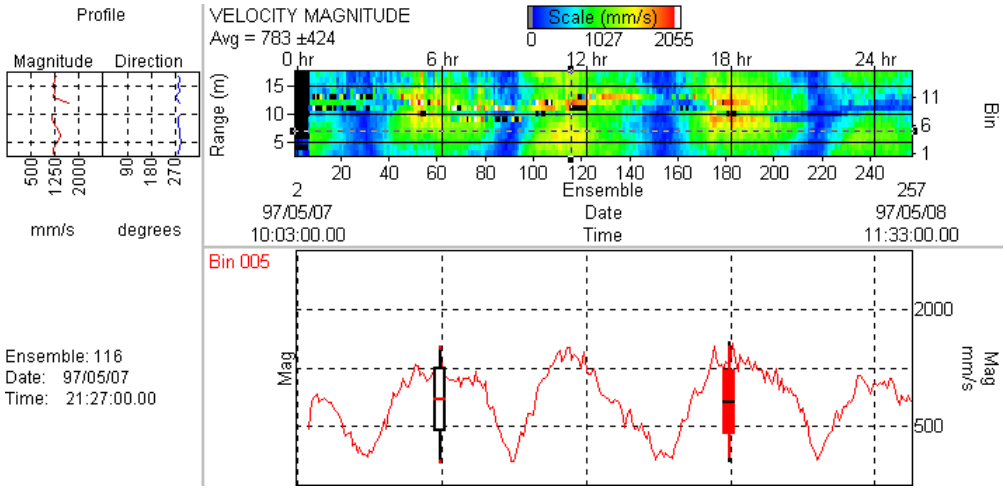


Figure 2. Sub Set

2.3 Selected Set

By holding down the **Spacebar** and then pressing the **Left** mouse button, the user can drag the mouse to select a portion of the entire data set. When the mouse button is released, the selected portion of the **Whole Set** is marked by a blinking box outline. The blinking box outlines a set of data called the **Selected Set**. A second blinking box is also created when the mouse is released. This second box is striped or solid depending on your graphics card. The solid blinking box marks a region of data called the **Sub**

Set. The width of the **Sub Set** box may not be as wide as the **Selected Set** box. The width of the **Sub Set** is dependent upon the **Options**, **Ensembles** setting selected from the main menu.

Figure 1, page 3 shows an example of the **Whole Set** contour display. The **Sub Set** contour display is identical except it does not show the **Selected** and **Sub Set** ensemble numbers (located in the upper right corner of the chart).

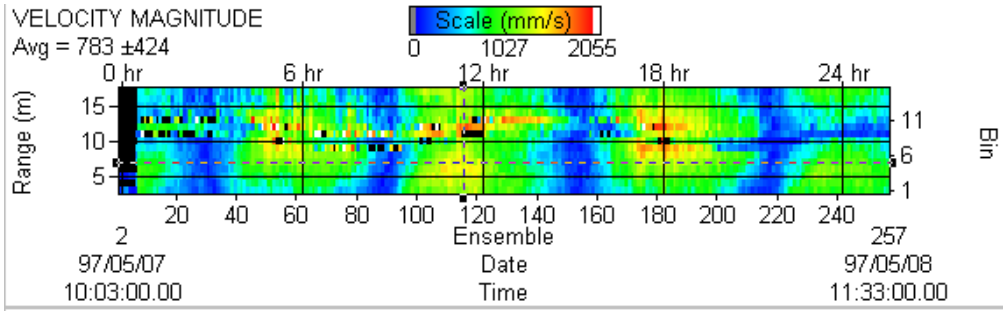


Figure 3. Selected Set

2.4 Profile Chart

The Profile chart, located on the left side of the **Sub Set** form, displays a user selected ensemble in several two dimensional (2D) charts. Each of these "sub charts" contains a different data type taken from the ensemble. The user can select the profile ensemble by double clicking the left mouse button just above or just below the **Sub Set** color contour.

NOTE. Use the **left** and **right** keyboard arrows to scroll through the ensembles. Use the **Animate** menu to automatically scroll through the data file. To quickly select an ensemble, double-click a point just above or below the **Sub Set** color contour plot.

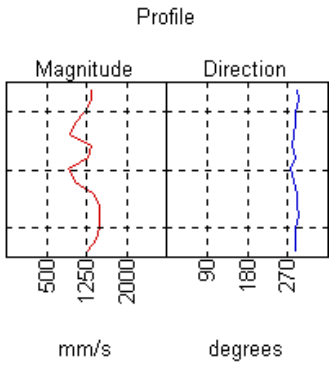


Figure 4. Profile Chart

2.5 Series Chart

The Series and Ancillary chart, located in the lower left-hand portion of **Sub Set**, displays user selected bins of user selected data types. In addition, the user may select any of the ancillary data types for display in this chart.

The candle chart shows the statistical information about the series chart. Use the **Options**, **Chart Options** menu to select the **Averaging Interval**. The candle chart will be centered on the averaging interval.

- The red line is the mean
- The middle rectangle shape is the Standard Deviation
- The long line shows the minimum and maximum values

NOTE. Double-click the candle chart to display the Series Trend and Residuals chart.

NOTE. Use the **up** and **down** keyboard arrows to scroll through the bins. Use the **Animate** menu to automatically scroll through the data file. To quickly select multiple bins, double-click a point just to the left or right of the color contour plot on the **Sub Set** color contour plot. Double clicking the same point will unselect the bin.

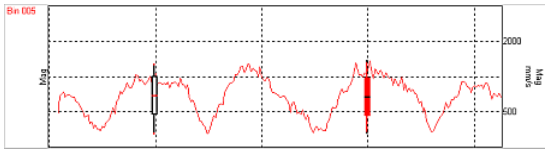


Figure 5. Series and Ancillary Chart

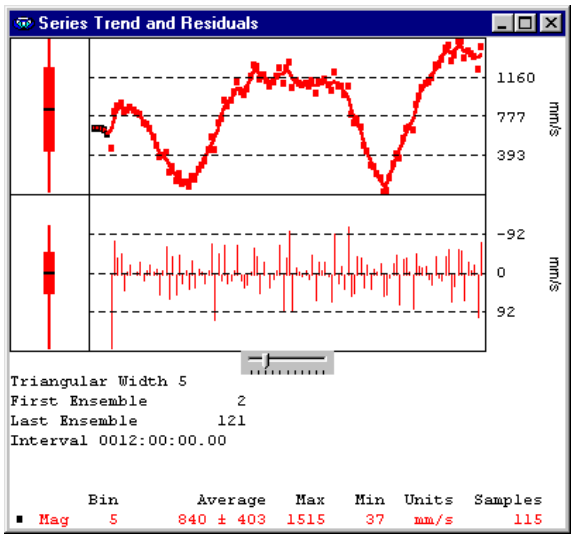


Figure 6. Series Trend and Residuals Chart

2.6 Track Vector Time Series

The **Track Vector Time Series** window displays two current vectors: one along a selected track and the other orthogonal to it (90 degrees). The user can select three different tracks: **Navigation**, **Bottom**, and **Projected**. **Navigation** and **Bottom** use actual data contained within the ADCP ensemble. The **Projected** angle is input by the user.

An application where this display is useful is in cable laying. Ocean currents across the path of a ship tend to pull a cable off to the side. Information about current magnitude and direction relative to the ship track helps to guide the ship for better cable placement.

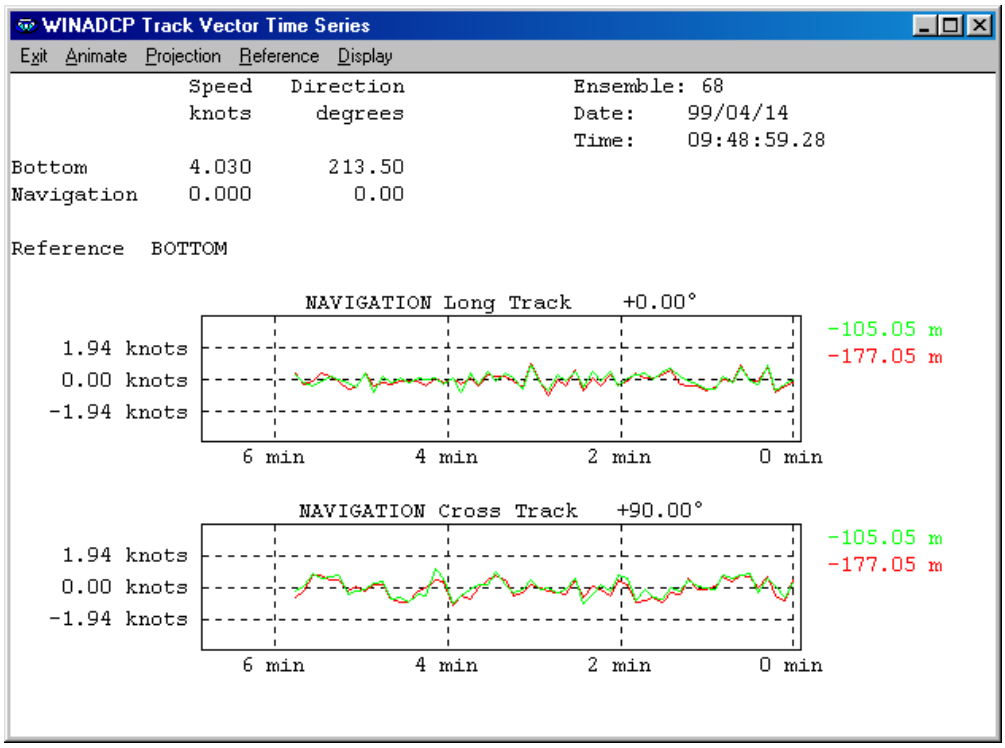


Figure 7. Track Vector Time Series

The **Track Vector Time Series** window has its' own menu.

Exit – Exits the **Track Vector Time Series** window. To display the window again, click **Window**, **Track Vector**.

Animate – Choose **Go** to animate the chart. **Stop** will stop the animation and **Rewind** will rewind the chart to the beginning of the file.

Projection – Choose between **Bottom Track**, **Navigation Track**, or **Manual**. If you select **Manual**, you can select your own projection angle.

Reference – Clicking **Reference** will display the **Chart Options** menu, **Processing** tab. Choose a reference from the list.

Display – Clicking **Display** will let you choose the **Units**, and **Font** for the display. Selecting **Time Origin on Left** will toggle the time origin being displayed on the right, to the left side of the display.

Clicking anywhere on the **Track Vector Time Series** display will display the **Chart Options** menu, **Series** tab. Choose the bins to display by selecting the bin box on the list.

NOTE. The **Animation** and **Reference** menus are disabled on the **Track Vector** window when the **Monitor** mode is enabled. All other menus are available.

Negative range numbers are shown when the system is downward facing (bins are below transducer). If the system is upward facing the range numbers are positive.

2.7 Saving Files

The **Selected** and **Sub Set** plots may be saved to new data files as needed.

2.7.1 Save a Sub Set File

On the **Whole Set** color contour plot, use the **Zoom** feature (see "Selected Set," page 3) to select the portion of the **Whole Set** to be displayed in the **Sub Set** color contour plot. You can use the zoom feature on the **Sub Set** color contour plot to further zoom in on the data.

a. On the **File** menu, click **Save Sub Set**.

b. Give the file a unique name. *WinADCP* does not add an extension type to the file. To organize data files, you may want to add the *.000 file extension.

c. Click **Save**.

CAUTION. If the file name already exists as a closed data file, then the file will be written over. You will be prompted if it is OK to overwrite the file.

NOTE. If the file name you select is the *same* as the currently open file then the **Sub Set** of data is not written to the file.

The **Sub Set** has a limit of 8,192 ensembles.

If the Binary Data File that was opened had segmented consecutive file names (i.e. DEMO001r.000, DEMO001r.001, DEMO001r.002) when you save the **Sub Set**, it will be saved as one file. Make sure you use a unique name to avoid overwriting a data file.

The format of the **Sub Set** file is the same as the raw ADCP Binary Data File format. **Sub Set** files may be opened with other RDI Software.

2.7.2 Save the Selected Set

On the **Whole Set** color contour plot, use the **Zoom** feature to select the **Selected Set**.

a. On the **File** menu, click **Save Selected Set**.

b. Give the file a unique name. *WinADCP* does not add an extension type to the file. To organize data files, you may want to add the *.000 file extension.

c. Click **Save**.

CAUTION. If the file name already exists as a closed data file, then the file will be written over. You will be prompted if it is OK to overwrite the file.

NOTE. If the file name you select is the *same* as the currently open file then the **Sub Set** of data is not written to the file.

The Selected Set does not have a limit on the number of ensembles.

If the Binary Data File that was opened had segmented consecutive file names (i.e. DEMO001r.000, DEMO001r.001, DEMO001r.002) when you save the Selected Set, it will be saved as one file. Make sure you use a unique name to avoid overwriting a data file.

The format of the Selected Set file is the same as the raw ADCP Binary Data File format. Selected Set files may be opened with other RDI Software.

2.8 Printing Charts

Charts may be copied to the Windows® clipboard so that they may be pasted or printed in other programs.

a. On the **Edit** menu, click **Copy**.

b. Select either the **Whole Set** or the **Sub Set**.

c. The chart will be placed on the Windows clipboard.

d. Open the graphic program (or Word) and select **Edit**, **Paste**.

e. Use the graphic program (or Word) to print the chart.

NOTE. If you use the **Edit**, **MSPAINT** menu the **Whole Set** or **Sub Set** will be placed as a Bit Map image on the Windows clipboard and will open the Microsoft Paint program. In Paint, select **Edit**, **Paste** to display the Bit Map.

The shortcut to the Microsoft Paint program expects the program to be in the default directory C:\Windows.

2.9 Flip

Selecting **Flip** from the **Edit** menu causes the file to be re-read with the orientation bit inverted. In other words, an upward facing data set appears as a downward set when **Flip** is clicked.

2.10 File Details

On the **Utilities** menu, click **File Details**. Select the data file to be examined. The file utility window will show you everything there is to know about the file contents.

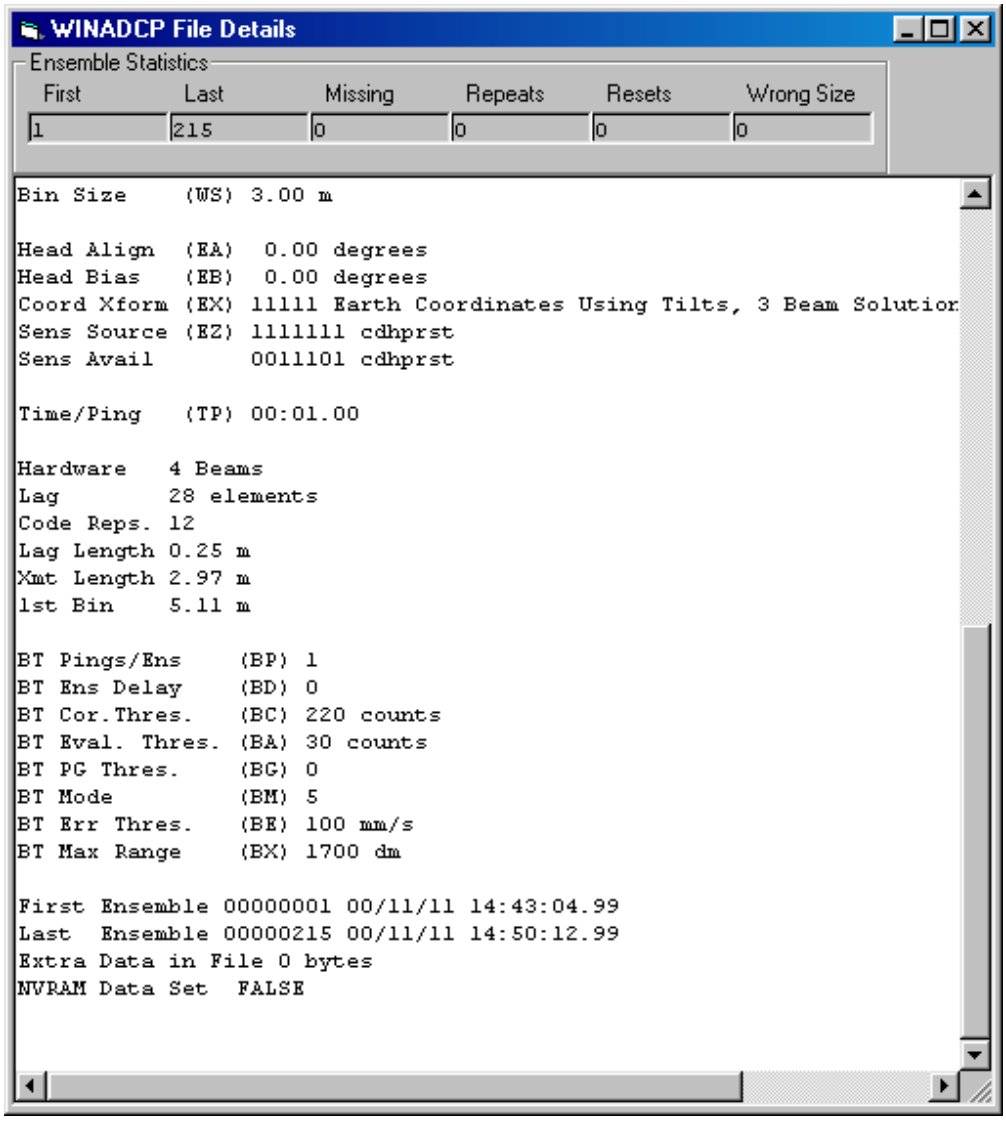


Figure 8. File Details

3 Chart Options

The **Options** menu controls how the displays are shown. Selecting **Chart Options** under the **Options** Menu brings up the **Chart Options** dialog box. There are five tabs on the dialog box:

- Contour Tab
- Profile Tab
- Series Tab
- Ancillary Tab
- Processing Tab

Six buttons are positioned along the bottom of the **Chart Options** dialog box.

Default - restores each of the four options pages to factory selected ones.

Load - reads in, from a selected file, a previously saved set of option pages.

Save - writes out, to a named file, the contents of the option pages.

OK - updates the screen to the new setting(s) and close the options dialog.

Cancel - close the options dialog.

Apply - update the screen to the new setting(s) but **does not** close the options dialog.

NOTE. Max Ensembles, under the **Options** menu, is used to set the maximum number of ensembles shown in both the **Sub Set Color Contour** and **Series** charts.

3.1 Contour Tab

The **Contour** tab has five control groups for controlling the **Whole Set**, **Sub Set** and color contour charts.

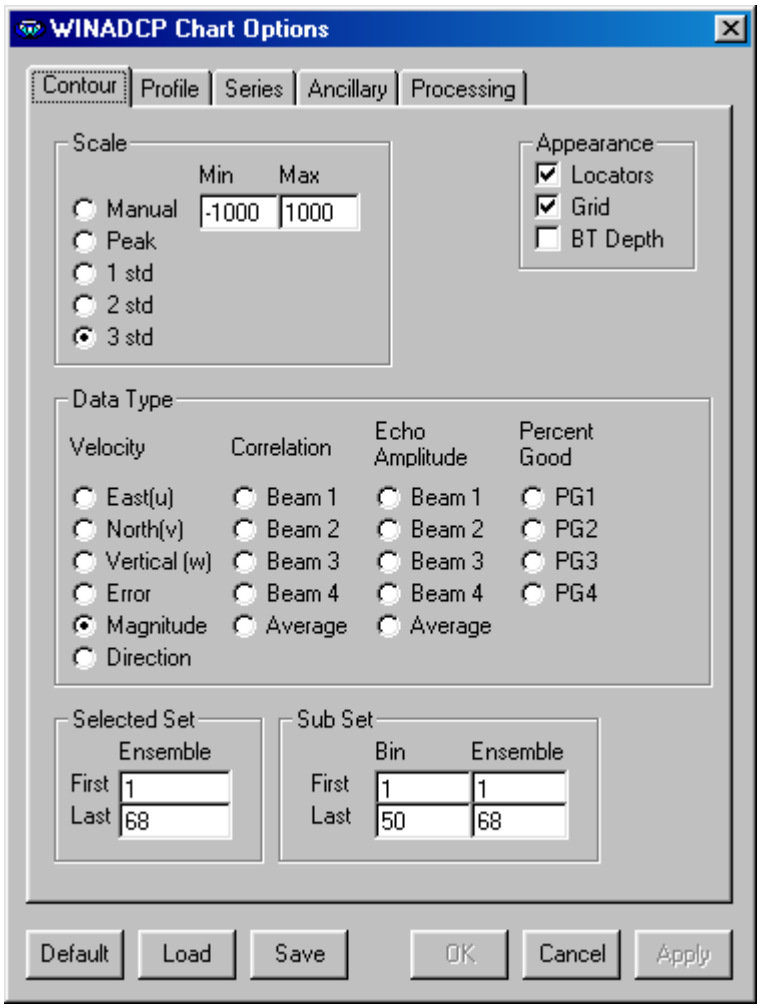


Figure 9. Contour Tab

Scale - Five choices for selecting the maximum and minimum values of the color scale.

- **Manual** - user entry of values.
- **Peak** - Automatic setting to the max/min values contained in the data set.
- **1 std** - Automatic setting to data mean plus and minus ONE standard deviation.
- **2 std** - same as above but TWO standard deviations.

- **3 std** - same as above but THREE standard deviations.

Appearance - Three check boxes.

- **Locators** - turn on/off the blinking boxes of the **Whole Set** color contour.
- **Grid** - turn on/off the grid that overlays both color contour charts.
- **BT Depth** – When checked and Bottom Track depth data is available, a bottom contour line is drawn on top of the color contour plot. If beam 1 through 4 RSSI or correlation is selected for display, the beams depth is shown. Any other selection will show the contour line as the average of the four beams.

Data Type - Used to select one of the data types for display.

Selected Set - Used to select the first and last ensembles of the Selected Set.

Sub Set - Used to select the first and last ensembles of the **Sub Set**.

3.2 Profile Tab

The **Profile** tab has four control groups for controlling the Profile chart.

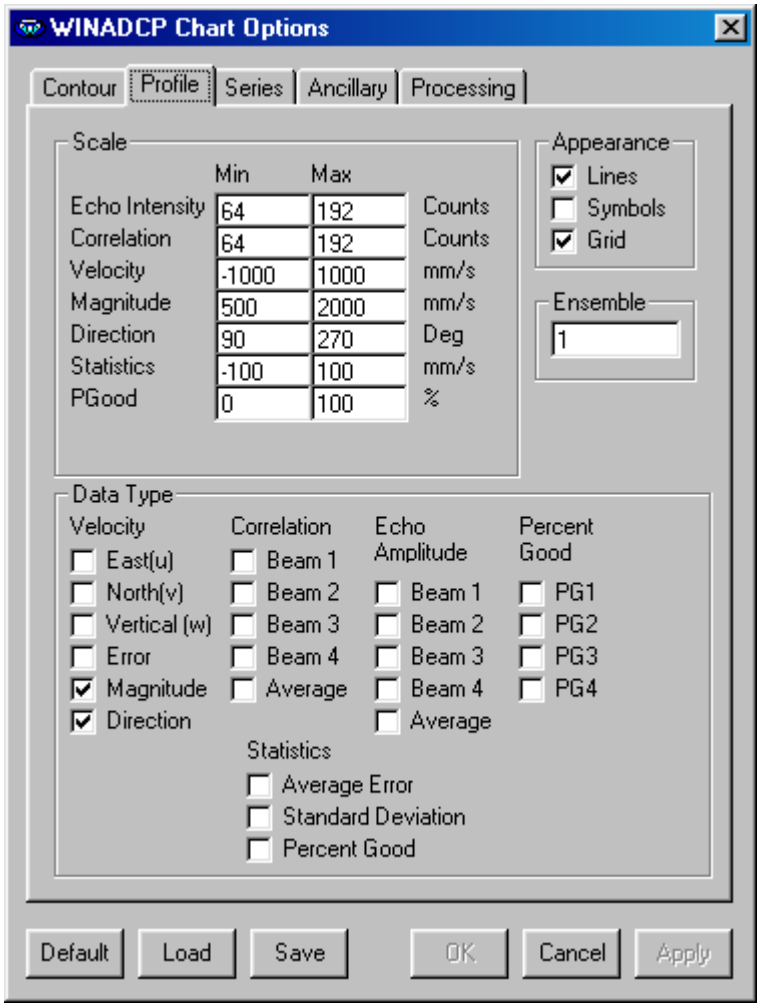


Figure 10. Profile Tab

Scale - Manual selection of the maximum and minimum values for each data type.

Appearance - Three check boxes.

- **Lines** - Turn on/off the connection of lines between data points.
- **Symbols** - Turn on/off a symbol at each data point location.
- **Grid** - Turn on/off the grids that overlay the profile charts.

Ensemble - Used to select the current ensemble.

Data Type - Used to select several of the data types for display.

3.3 Series Tab

The Series tab has five control groups for controlling the Series chart.

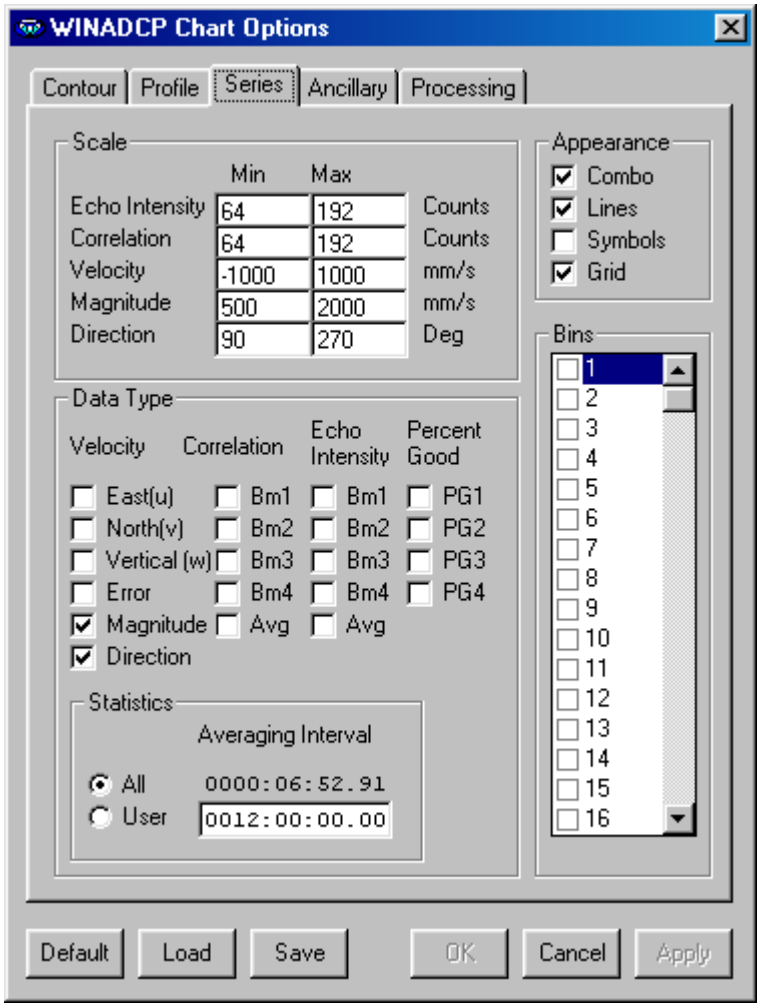


Figure 11. Series Tab

Scale - Manual selection of the maximum and minimum values for each data type.

Appearance - Four check boxes.

- **Combo** - When selected each bin of a data type is plotted on the same chart.
- **Lines** - Turn on/off the connection of lines between data points.
- **Symbols** - Turn on/off a symbol at each data point location.
- **Grid** - Turn on/off the grids that overlay the series charts.

Data Type - Selects several of the data type for display.

Statistics - Selects the time interval over which statistics are calculated.

- **All** - The total time of the **Sub Set** data.
- **User** - Used when several statistic sets over the **Sub Set** interval are desired.

Bins - Selects which bin to display.

3.4 Ancillary Tab

The Ancillary tab has three control groups for controlling the Ancillary chart.

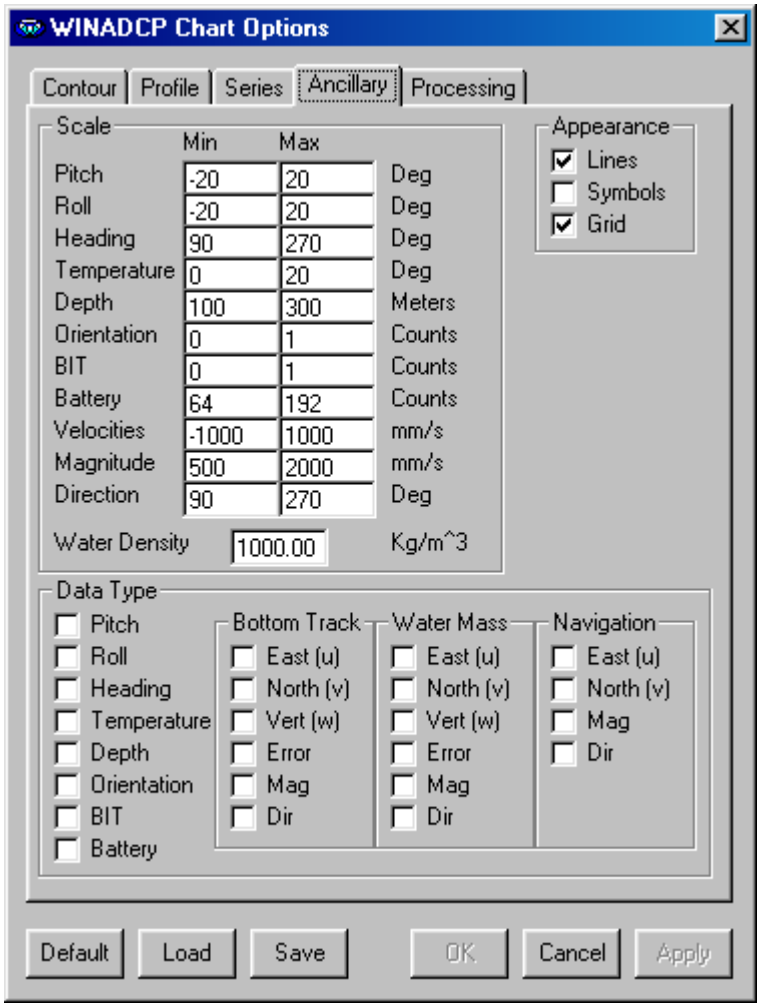


Figure 12. Ancillary Tab

Scale - Manual selection of the maximum and minimum values for each data type.

Appearance - Three check boxes.

- Lines - Turn on/off the connection of lines between data points.
- Symbols - Turn on/off a symbol at each data point location.
- Grid - Turn on/off the grids that overlay the ancillary charts.

Data Type - Selects several of the data type for display.

NOTE. Water density is used to convert pressure to depth, if the pressure data is available.

3.5 Processing Tab

The Processing tab allows the selection of a velocity reference; **None**, **Bottom Track**, or **Navigation**.

NOTE. The Navigation is *VmDas* format.

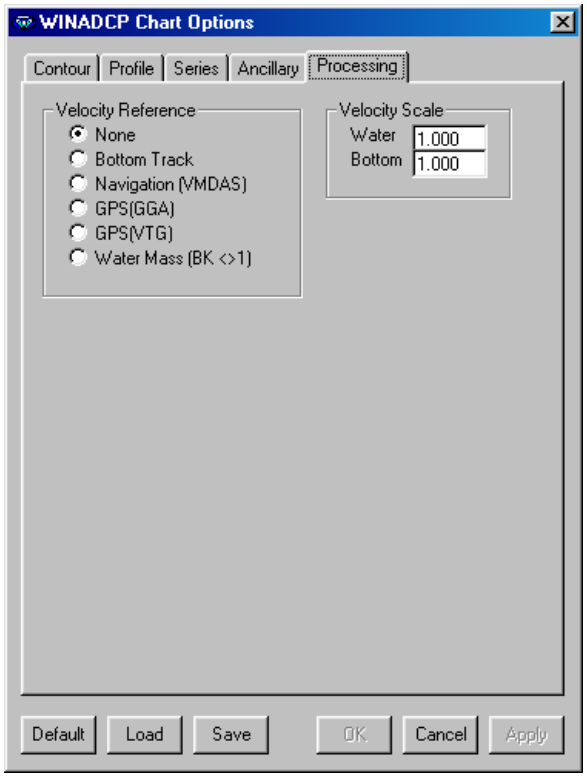


Figure 13. Processing Tab

4 Exporting Data

Clicking the main menu item **Export** brings up the *WinADCP* **Export Options** dialog box. There are three styles of export: **Contour**, **Profile**, and **Series**/**Ancillary**.

The MAT file output has a MatLab compatible binary format. From MatLab type **load filename.mat** then type **who**. The Column = Bin and Row = Ensemble. A list of variables for each output format is shown.

4.1 Contour

Exporting contour data allows the selection of one data type (**Velocity**, **Magnitude**, **Amplitude**, **Correlation**, and **Percent Good**), the first/last ensembles, the first/last bins, and the file format.

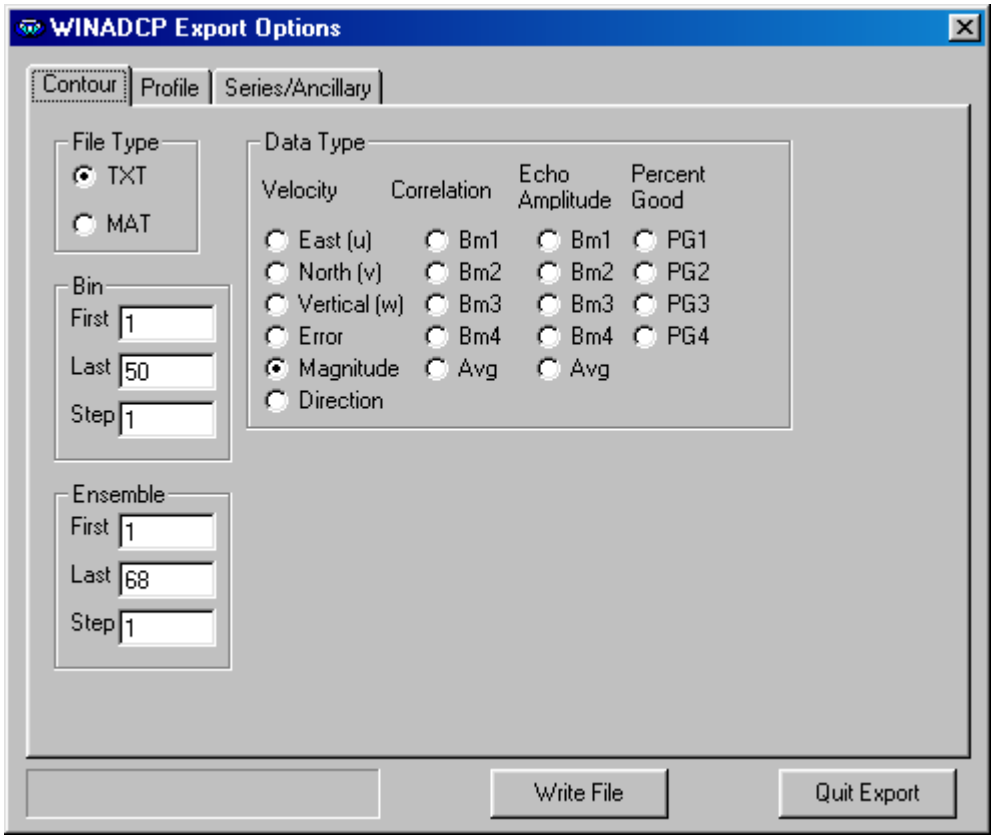


Figure 14. Export Data - Contour

4.2 Profile

Exporting Profile data allows the selection of many data types, one ensemble, the first/last bins, and the file format.

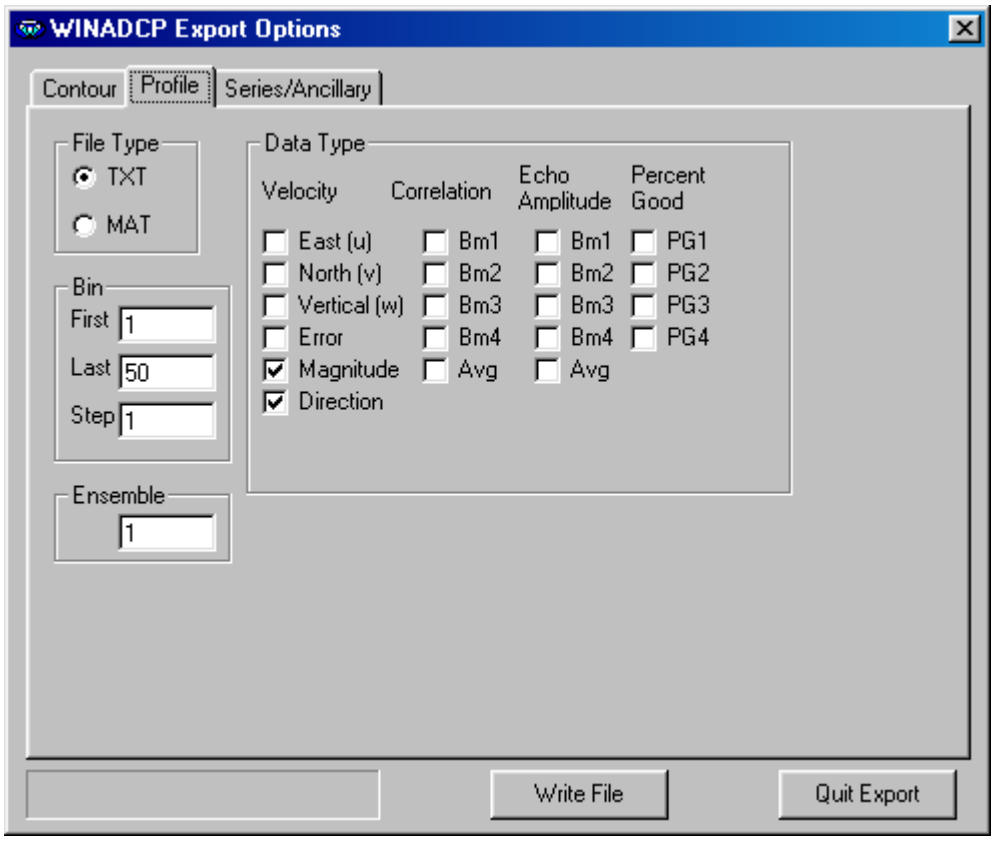


Figure 15. Export Data - Profile

4.3 Series/Ancillary

Exporting Series/Ancillary data allows the selection of many data types, the first/last ensembles, the first/last bins (of the series data), and the file format.

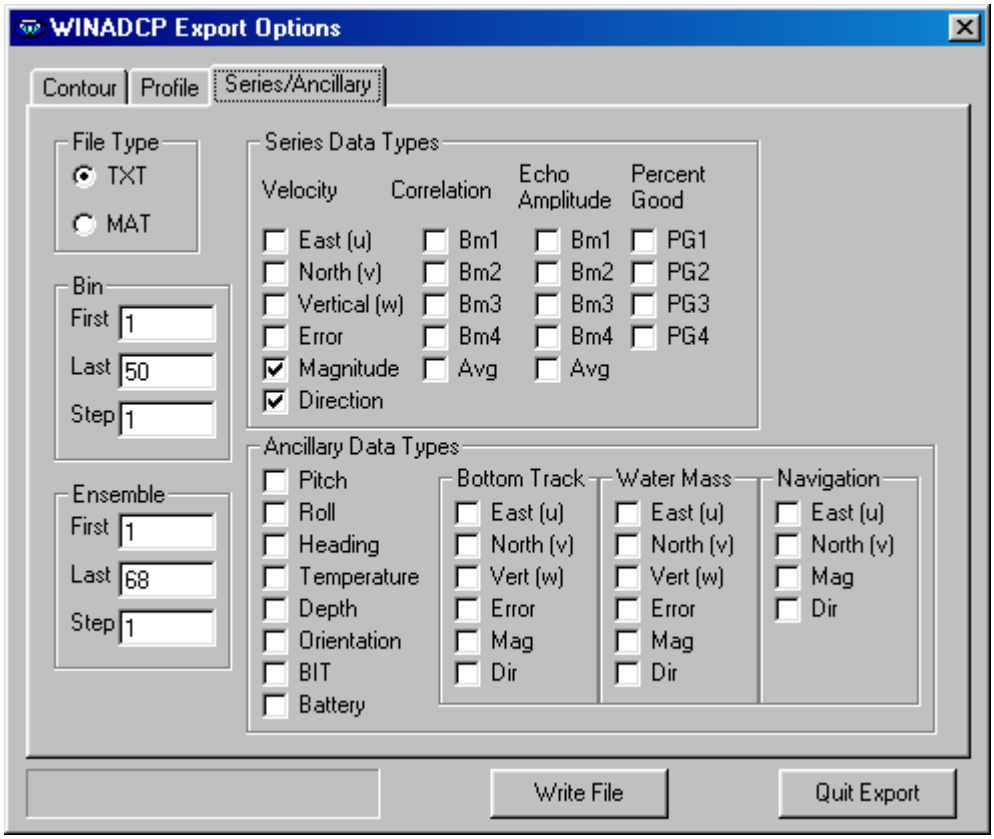


Figure 16. Export Data – Series/Ancillary

5 Monitor Mode

WinADCP has the ability to automatically update the reading of a file as real-time data collection is occurring. When the file size increases, (due to real-time data collection in another program such as *VmDas*) **Monitor** will automatically reread the file at selected intervals and display the contents. When **Monitor** is enabled and the file size is changing, all menu items except **Monitor** will be unavailable. You can change the interval by clicking **Monitor**, **Interval**. Enter the monitor interval in seconds.

NOTES

ATTACHMENT 3
SURVEY EQUIPMENT DATA SHEETS

Workhorse Sentinel

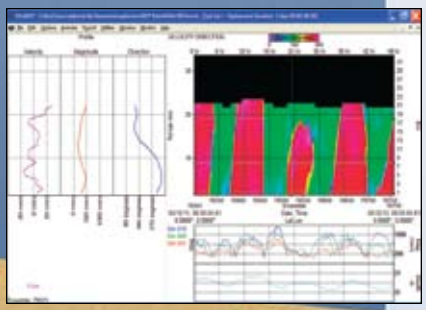
SELF-CONTAINED 1200, 600, 300 kHz ADCP

The Global Leader in High-accuracy Data Collection

The self-contained **Sentinel** is Teledyne RD Instruments' most popular and versatile Acoustic Doppler Current Profiler (ADCP) configuration, boasting thousands of units in operation in over 50 countries around the world.

By providing profiling ranges from 1 to 165m, the high-frequency Sentinel ADCP is ideally suited for a wide variety of applications. Thanks to Teledyne RDI's patented Broadband signal processing, the Sentinel also offers unbeatable precision, with unmatched low power consumption, allowing you to collect more data over an extended period.

The lightweight and adaptable Sentinel is easily deployed on buoys, boats, or mounted on the seafloor. Real-time data can be transmitted to shore via a cable link or acoustic modem, or data can be stored internally for short or long-term deployments. The Sentinel is easily upgraded to include pressure, bottom tracking, and/or directional wave measurement—for the ultimate data collection solution.



The Workhorse Sentinel offers:

- **Versatility:** *Direct reading or self contained, moored or moving, the Sentinel provides precision current profiling data when and where you need it most.*
- **A solid upgrade path:** *The Sentinel has been designed to grow with your needs. Easy upgrades include pressure, bottom tracking, and directional wave measurement.*
- **Precision data:** *Teledyne RDI's patented BroadBand signal processing delivers very low-noise data, resulting in unparalleled data resolution and minimal power consumption.*
- **A four-beam solution:** *Teledyne RDI's patented 4-beam design improves data reliability by providing a redundant data source in the case of a blocked or damaged beam; improves data quality by delivering an independent measure known as error velocity; and improves data accuracy by reducing variance in your data.*

MEASURING WATER IN MOTION

TELEDYNE
RD INSTRUMENTS
A Teledyne Technologies Company

Workhorse Sentinel

SELF-CONTAINED 1200, 600, 300 kHz ADCP

Technical Specifications

Water Profiling						
Depth	*Typical Range[2] 12m*		*Typical Range[2] 50m*		*Typical Range[2] 110m*	
Cell Size[1]	**1200kHz**		**600kHz**		**300kHz**	
Vertical Resolution (m)	Range[3] (m)	Std. Dev.[4] (cm/s)	Range[3] (m)	Std. Dev.[4] (cm/s)	Range[3] (m)	Std. Dev.[4] (cm/s)
0.25m	*11–14*	*12.9*				
0.5m	*13–16*	*6.1*	*39*	*12.9*	*see note [1]*	
1m	*14–18*	*3.0*	*43*	*6.1*	*92–71*	*12.8*
2m	*15–20[2]*	*2.0*	*47*	*3.0*	*102–78*	*6.1*
4m	*see note [1]*		*52[2]*	*2.0*	*113–86*	*3.0*
8m					*126–95[2]*	*2.0*

[1] User's choice of depth cell size is not limited to the typical values specified.
[2] Longer ranges available.
[3] Profiling range based on temperature values at 5°C and 20°C, salinity = 35ppt.
[4] BroadBand mode single-ping standard deviation (Std. Dev.).

Long Range Mode

	Range (m)	Depth Cell Size (m)	Std. Dev. (cm/s)
1200kHz	24	2	3.8
600kHz	70	4	4.2
300kHz	165	8	4.2

Profile Parameters

Velocity accuracy:

- **1200, 600:** 0.3% of the water velocity relative to the ADCP ±0.3cm/s
- **300:** 0.5% of the water velocity relative to the ADCP ±0.5cm/s

Velocity resolution: 0.1cm/s
Velocity range: ±5m/s (default)
±20m/s (maximum)
Number of depth cells: 1–128
Ping rate: 2Hz (typical)

Echo Intensity Profile

Vertical resolution: Depth cell size
Dynamic range: 80dB
Precision: ±1.5dB

Transducer and Hardware

Beam angle: 20°
Configuration: 4-beam, convex
Internal memory: Two PCMCIA card slots; one memory card included
Communications: Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200-115,200 baud.

Standard Sensors

Temperature (mounted on transducer):
Range: -5° to 45°C
Precision: ±0.4°C
Resolution: 0.01°

Tilt: Range: ±15°
Accuracy: ±0.5°
Precision: ±0.5°
Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature):
Accuracy: ±2° [5]
Precision: ±0.5° [5]
Resolution: 0.01°
Maximum tilt: ±15°

[5] <±1.0° is commonly achieved after calibration

Power

External DC input: 20–50VDC
Internal battery voltage: 42VDC new; 28VDC depleted
Battery capacity: @0°C: 450 watt hours

Environmental

Standard depth rating:
200m; optional to 6000m
Operating temperature: -5° to 45°C
Storage temperature*: -30° to 60°C
Weight in air: 13.0kg
Weight in water: 4.5kg
** Without batteries*

Software

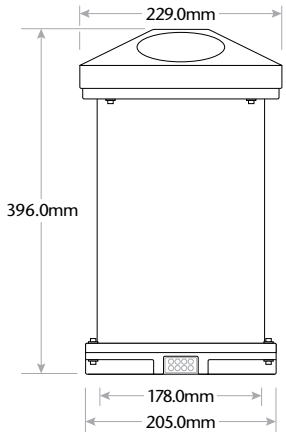
Teledyne RDI's Windows™-based software included:

- WinSC—Data Acquisition
- WinADCP—Data Display and Export

Available Options

- Memory: 2 PCMCIA slots, total 4GB
- Pressure sensor
- External battery case
- High-resolution water-profiling modes
- Bottom tracking
- AC/DC power converter, 48VDC output
- Pressure cases for depths up to 6000m
- Directional Wave Array

Dimensions



TELEDYNE
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Tel. +33-49-211-0930 • Fax +33-49-211-0931 • E-mail: rdie@teledyne.com

Free online product training
Free 24/7 emergency support

Specifications subject to change without notice.
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YSI Environmental

YSI 6820 and 6920 V2 Sondes

With 1 or 2 optical ports and new sensor options

The YSI 6820 V2-2 and 6920 V2-2 Sondes

Measure multiple parameters simultaneously including:

Temperature
Conductivity
Specific Conductance
Salinity
Resistivity
TDS
pH
ORP
Depth or Level
Nitrate, Ammonium or Chloride
Rapid Pulse™ DO (V2-1 only)

And 1 or 2 of the following optical sensors:

ROX™ Optical DO
Turbidity
Chlorophyll
Blue-Green Algae
(Phycocyanin or Phycoerythrin)
Rhodamine

- **Two bulkhead versions available:**
  - **The 6820/6920 V2-1 has one optical port, conductivity/ temperature port, Rapid Pulse™ DO port, pH/ORP port. and three ISE ports**
  - **The 6820/6920 V2-2 has two optical ports, conductivity/ temperature port, pH/ORP port. and one ISE port**
- **Self-cleaning optical sensors with improved wiping**
- **Field-replaceable sensors**
- **6920 V2 has a built-in battery compartment for long-term *in situ* monitoring**

Take Advantage of YSI's New Optical Sensors

In addition to turbidity, chlorophyll, and rhodamine, YSI now offers these optical sensors:

ROX Reliable Optical Dissolved Oxygen

The ROX sensor uses lifetime luminescence detection technology to offer the most reliable oxygen sensor with the lowest possible maintenance effort. Experience significantly less membrane maintenance while obtaining excellent accuracy, sensitivity, and range.

Blue-Green Algae (BGA)

YSI's fluorescence-based blue-green algae sensors will allow you to monitor blue-green algae populations where their presence is a concern. Whether providing an early warning to an algal bloom, tracking taste and odor-causing species in drinking water supplies, or conducting ecosystem research; YSI BGA sensors will provide sensitive and reliable *in situ* data.

6820 and 6920 Upgrades Available

YSI is committed to offering our customers reliable and cost-effective water monitoring solutions. To this end, we are offering V2-2 Upgrades for existing 6820/6920s. Upgrades will be available from YSI Authorized Service Centers and will include the new 6820/6920 V2-2 bulkhead, an Optical Dissolved Oxygen Sensor, and firmware/software upgrades. In addition, the sonde will be fully tested and calibrated by an experienced YSI service technician.

Pure Data for a Healthy Planet.®

Compact sondes for field sampling and data collection platforms

To order, or for more info, contact YSI Environmental.

+1 937 767 7241
800 897 4151 (US)
www.ysi.com

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+1 937 767 7241
Fax +1 937 767 9353
environmental@ysi.com

YSI Integrated Systems & Services
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ISO 9001
ISO 14001
Yellow Springs, Ohio Facility

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CE

*Sensors with listed with the ETV logo were submitted to the ETV program on the YSI 6600EDS. Information on the performance characteristics of YSI water quality sensors can be found at www.epa.gov/etv, or call YSI at 800.897.4151 for the ETV verification report. Use of the ETV name or logo does not imply approval or certification of this product nor does it make any explicit or implied warranties or guarantees as to product performance.

YSI incorporated
Who's Minding the Planet?®

YSI 6820 V2 & 6920 V2 Sensor Specifications

	Range	Resolution	Accuracy
ROX™ Optical Dissolved Oxygen• % Saturation	0 to 500%	0.1%	0 to 200%: ±1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ±15% of reading, relative to calibration gases
ROX™ Optical Dissolved Oxygen• mg/L	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L: ± 0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: ±15% of reading, relative to calibration gases
Dissolved Oxygen•• % Saturation ETV 6562 Rapid Pulse™ Sensor*	0 to 500%	0.1%	0 to 200%: ±2% of reading or 2% air saturation, whichever is greater; 200 to 500%: ±6% of reading
Dissolved Oxygen•• mg/L ETV 6562 Rapid Pulse™ Sensor*	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L: ± 0.2 mg/L or 2% of reading, whichever is greater; 20 to 50 mg/L: ±6% of reading
Conductivity••• ETV 6560 Sensor*	0 to 100 mS/cm	0.001 to 0.1 mS/cm (range dependent)	±0.5% of reading + 0.001 mS/cm
Salinity	0 to 70 ppt	0.01 ppt	±1% of reading or 0.1 ppt, whichever is greater
Temperature ETV 6560 Sensor*	-5 to +50°C	0.01°C	±0.15°C
pH ETV 6561 Sensor*	0 to 14 units	0.01 unit	±0.2 unit
ORP	-999 to +999 mV	0.1 mV	±20 mV
Depth Medium Shallow Vented Level	0 to 200 ft, 61 m 0 to 30 ft, 9.1 m 0 to 30 ft, 9.1 m	0.001 ft, 0.001 m 0.001 ft, 0.001 m 0.001 ft, 0.001 m	±0.4 ft, ±0.12 m ±0.06 ft, ±0.02 m ±0.01 ft, 0.003 m
Turbidity• ETV 6136 Sensor*	0 to 1,000 NTU	0.1 NTU	±2% of reading or 0.3 NTU, whichever is greater**
Nitrate/nitrogen••••	0 to 200 mg/L-N	0.001 to 1 mg/L-N (range dependent)	±10% of reading or 2 mg/L, whichever is greater
Ammonium/ammonia/ nitrogen••••	0 to 200 mg/L-N	0.001 to 1 mg/L-N (range dependent)	±10% of reading or 2 mg/L, whichever is greater
Chloride••••	0 to 1000 mg/L	0.001 to 1 mg/L (range dependent)	±15% of reading or 5 mg/L, whichever is greater
Rhodamine•	0-200 µg/L	0.1 µg/L	±5% reading or 1 µg/L, whichever is greater

• Maximum depth rating for all standard optical sensors is 200 feet, 61 m.
•• Rapid Pulse is only available on the 6820/6920 V2-1 (one optical port version)
••• Report outputs of specific conductance (conductivity corrected to 25° C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (ed 1989).
•••• Freshwater only, Maximum depth rating of 50 feet, 15.2 m. 6820/6920 V2-1 have 3 ISE ports, 6820/6920 V2-2 have 1 ISE port.

**In YSI AMCO-AEPA Polymer Standards.

	Range	Detection Limit	Resolution	Linearity
BGA - Phycocyanin•	~0 to 280,000 cells/mL† 0 to 100 RFU	~220 cells/mL§	1 cell/mL 0.1 RFU	$R^2 > 0.9999$**
BGA - Phycoerythrin•	~0 to 200,000 cells/mL† 0 to 100 RFU	~450 cells/mL§§	1 cell/mL 0.1 RFU	$R^2 > 0.9999$***
Chlorophyll• ETV 6025 Sensor*	~0 to 400 µg/L 0 to 100 RFU	~0.1 µg/L§§§	0.1 µg/L Chl 0.1% RFU	$R^2 > 0.9999$****

• Maximum depth rating for all standard optical probes is 200 feet, 61 m.
BGA = Blue-Green Algae
RFU = Relative Fluorescence Units
~ = Approximately

† Explanation of Ranges can be found in the 'Principles of Operation' section of the 6-Series Manual, Rev D.

§ Estimated from cultures of *Microcystis aeruginosa*.
§§ Estimated from cultures *Synechococcus sp.*
§§§ Determined from cultures of *Isochrysis sp.* and chlorophyll *a* concentration determined via extractions.

**Relative to serial dilution of Rhodamine WT (0-400 ug/L).
***Relative to serial dilution of Rhodamine WT (0-8 µg/L).
****Relative to serial dilution of Rhodamine WT (0-500 ug/L).

YSI 6820 V2 & 6920 V2 Sonde Specifications

Medium		Fresh, sea or polluted water	Software		EcoWatch®
Temperature	Operating Storage	-5 to +50°C -10 to +60°C	Dimensions 6820 V2 I 6920 V2	Diameter Length Weight	2.86 in, 7.3 cm | 2.85 in, 7.24 cm 13.5 in, 34.3 cm | 18 in, 45.7 cm 3.4 lbs, 1.5 kg | 4 lbs, 1.8 kg
Communications		RS-232, SDI-12	Power	External Internal	12 V DC 8 AA-size alkaline batteries

January 27, 2011

Surface Buoys

Bottom Mounts

Subsurface Buoyancy

Instrument Frames

Pier Mounted Installations

3 x 19 Wire Rope

Sediment Coring

Rigging & Hardware

MINIATURIZED TRAWL RESISTANT BOTTOM MOUNT (MTRBM) SYSTEMS

Protecting Instruments From Trawlers

Mooring Systems, Inc. manufactures a trawl resistant bottom mount designed for protecting oceanographic instrumentation from trawler gear.

These instrument platforms are ideally suited for use with up looking Doppler profilers, and provide sufficient space for extra battery housings, and other instrumentation.

Custom Designed Bottom Mount Systems

Optional diver serviceable instrument mounts and acoustically activated pop-up buoys are available to suit specific applications.

The basic construction of our MTRBM consists of a truncated rectangular fiberglass cover over a fiberglass grate.

Purge holes in the upper perimeter of the cover, and handles are standard. Holes in the top surface are placed as needed to meet instrument mounting requirements.

Options:

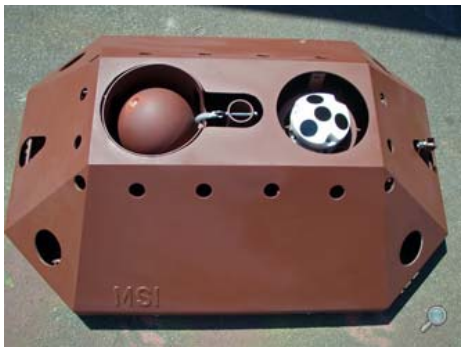
- Dual Axis Gimbals for Doppler Profilers
- Custom Instrument Mounting Brackets
- Recovery System (Pop-up Buoy) (Not on Micro Version)
- Center Deployment and Recovery Post
- Center Deployment Ring (Micro Version)
- Lead Ballast
- Anti-Foul Paint

MTRBM System Specifications:

Model:	Micro-MTRBM	Standard MTRBM
Cover Material	1/4" (6.4 mm) fiberglass	1/4" (6.4 mm) fiberglass
Base Material	1" (25.4 mm) fiberglass	1" (25.4 mm) fiberglass
Gimbals	PVC / stainless	PVC / stainless
Fasteners	316 stainless	316 stainless
Length	52" (1320 mm)	70" (1775 mm)
Width	42" (1067 mm)	48" (1220 mm)
Height (Outside)	14" (355 mm)	18.5" (470 mm)
Height (Inside)	11" (280 mm)	17.25" (438 mm)
Weight In Air	80 lbs. (36 kg) empty	132 lbs. (60 kg) empty
Weight In Water	30 lbs. (14 kg) empty	50 lbs. (23 kg) empty

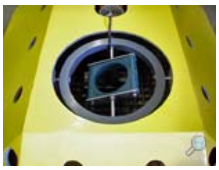
If you have any questions, feel free to contact us.

TOP



Above: Standard MTRBM system manufactured by MSI

Above: Micro-MTRBM system (left) manufactured by MSI



Above Left: Gimbal mount for ADCP, ADP, AWAC
Above Right: Center deployment and recovery post

More photos are available in the photo gallery ⟶

TRIPOD BOTTOM MOUNT SYSTEMS

Gimbaled ADCP Platforms

Mooring Systems, Inc. manufactures a lightweight tripod style bottom mount.

This open version instrument platforms is ideally suited for use with upward looking Acoustic Doppler Current Profilers.

Gimbaled mounting hardware provides proper orientation of the transducer head on sloping sea-beds.

Additional mounting is available on the tripod braces for extra battery housings, and other instrumentation.

An optional acoustically activated pop-up buoy with high strength Spectra line to hoist the platforms on deck allows recovery without the use of divers.

Features:

- Dual Axis Gimbals
- Lightweight Construction
- Knocks Down for Compact Transportation
- Corrosion Resistant 6061 Aluminum
- Zinc Anodes for Added Protection
- Removable Lead Ballast
- Welded Pick-Up Bail
- Lowering Eyes (2)
- Powder Coat or Epoxy Paint Finishes
- Brackets for Additional Instrument Housings

Tripod Mount Specifications:

Frame Material	6061 Aluminum
Dual Axis Gimbals	PVC
Fasteners, Eye Nuts	316 Stainless Steel
Angle of Legs	45 degrees
Overall Height	20" (0.5m)
Overall Diameter	60" (1.5m)
Air Weight	68 lbs. (31 kg) w/ Lead Ballast
Water Weight	56 lbs. (25 kg) w/ Lead Ballast
Standard Lead Ballast	30 lbs. (13.6 kg)

If you have any questions, feel free to contact us.

TOP

Above: Open tripod with yellow painted finish

Above: Tripod with bright unpainted finish

More photos are available in the photo gallery ⟶

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Surface Buoys
Bottom Mounts
Subsurface Buoyancy
Instrument Frames
Pier Mounted Installations
3 x 19 Wire Rope
Sediment Coring
Rigging & Hardware

Mooring Systems, Inc.
P.O. Box 413
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Cataumet, MA 02534
Phone: 508-564-4770
Fax: 508-564-4773
sales@mooringsystems.com

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ATTACHMENT 4
FIELD FORMS

	FIELD CHANGE REQUEST	Project Number:

Field Change No.
Page _____ to

Project Number:
Project Name:

CHANGE REQUEST
Applicable Reference:
Description of Change:

Reason for Change:

Impact on Present and Completed Work:

Requested by:
Date: ____/____/

(Field Scientist)

Acknowledged by:
Date: ____/____/

(Field Task Leader)

FIELD OPERATIONS MANAGER RECOMMENDATION

Recommended Disposition:

Recommendation by:
Date: ____/____/

(Sampling and Analysis Coordinator)

PROJECT MANAGER APPROVAL

Final Deposition:

Approved/Disapproved by:
Date: ____/____/

(CERCLA Coordinator)

ATTACHMENT 5
USEPA COMMENTS AND RESPONSES

Comment No.	Section	Page	Line	Comment	Response to Comment - Proposed Revision
1	General			Aside from location, are there any differences between the proposed 2011 ADCP experiment and the 2010 ADCP experiment? Also, how will the 2010 ADCP data be incorporated into the model calibration?	The two ADCP deployments are similar in that current velocity data was or will be obtained over an approximate two-month period. The 2010 ADCP location was placed relatively close to the waste impoundments because the original focus of that data collection effort was to support TCRA design activities. The 2011 ADCP location was chosen to obtain data that are representative of hydrodynamic conditions further away from the waste impoundments. The current velocity data collected during 2011 will be used to calibrate the hydrodynamic model, while the 2010 data will be used for model validation. Based on modeling experience at other sites, using tidal elevation and current velocity data collected at two locations within the study area to calibrate and validate the hydrodynamic model will provide sufficient confidence in the predictive capability of the model for the entire study area. The calibrated hydrodynamic model will provide transport information that will be used by the sediment transport model; however, re-calibration of the hydrodynamic model during development of the sediment transport is not required or expected.
2	General			The current velocity study will take place concurrent with the upstream sediment load study. What is the proposal to address concerns that the coupling of the two data sets may effectively be negated since the sediment load study location appears to be significantly distant from the velocity study?	The TSS concentration data will be used for estimating the upstream sediment load and also for evaluating the performance of the sediment transport model. The current velocity data will be used to calibrate and validate the hydrodynamic model. Thus, the two datasets are independent of each other, and co-location of sampling stations is not required. See additional information in response to comment #3.
3	Section 1.1 Overview			How was 10,000 cfs determined to be a high-flow event (e.g., the two-year return event is 38,400 cfs)? During the recent March 29, 2011 conference call, discharge values were discussed and it was conveyed that Lake Houston outflows are being used at least in part... but where is this data located?	The average flow rate in the San Jacinto River is 2,200 cfs. The 10,000 cfs criterion was chosen because this flow rate is about five times greater than the average flow rate. Flow rate data for the San Jacinto River are available from two different sources. First, Coastal Water Authority data are available at the Lake Houston Dam beginning in 2007[1]. Flow rate at the dam is calculated based on a relationship between lake water level and the geometry of the dam. Second, for the period prior to 2007, daily average flow rates at the dam are estimated by summing up flow rate data from six USGS gauges located upstream of Lake Houston and prorating the summed flow rate by the ratio of the drainage area at the dam (2,828 square miles) to the sum of the drainage areas of the six upstream gauges (2,075 square miles), which produces a drainage area proration factor of 1.36. The six USGS gauges are: Luce Bayou above Lake Houston near Huffman, Texas (08071280); East Fork San Jacinto River near New Caney, Texas (08070200); Caney Creek near Splendora, Texas (08070500); West Fork San Jacinto River above Lake Houston near Porter, Texas (08068090); Cypress Creek near Westfield, Texas (08069000); and Spring Creek near Spring, Texas (08068500)[2]. Based on previous experience on other systems, the transition from low/moderate flow conditions typically occurs when the flow rate is about two to five times the average flow rate. This transition can be observed in typical sediment rating curves (i.e., TSS concentration vs. flow rate) which show the following behavior: 1) TSS concentration is not correlated to flow rate when the flow rate is less than one to two times the long-term average flow rate; and 2) TSS concentration increases with increasing flow rate when the flow rate is greater than one to two times the average discharge value. Examples of

[1] Lake Houston Dam flow data obtained in March 2011 via personal email communication with Mike Kent (mkent@cwalps.org) from the Coastal Water Authority (http://www.coastalwaterauthority.org).
[2] Daily-average flow data can be obtained from the USGS National Water Information System (http://waterdata.usgs.gov/nwis/dv/?referred_module=sw). Access to each gauge station is by entering the Site Number (e.g., 08068500).

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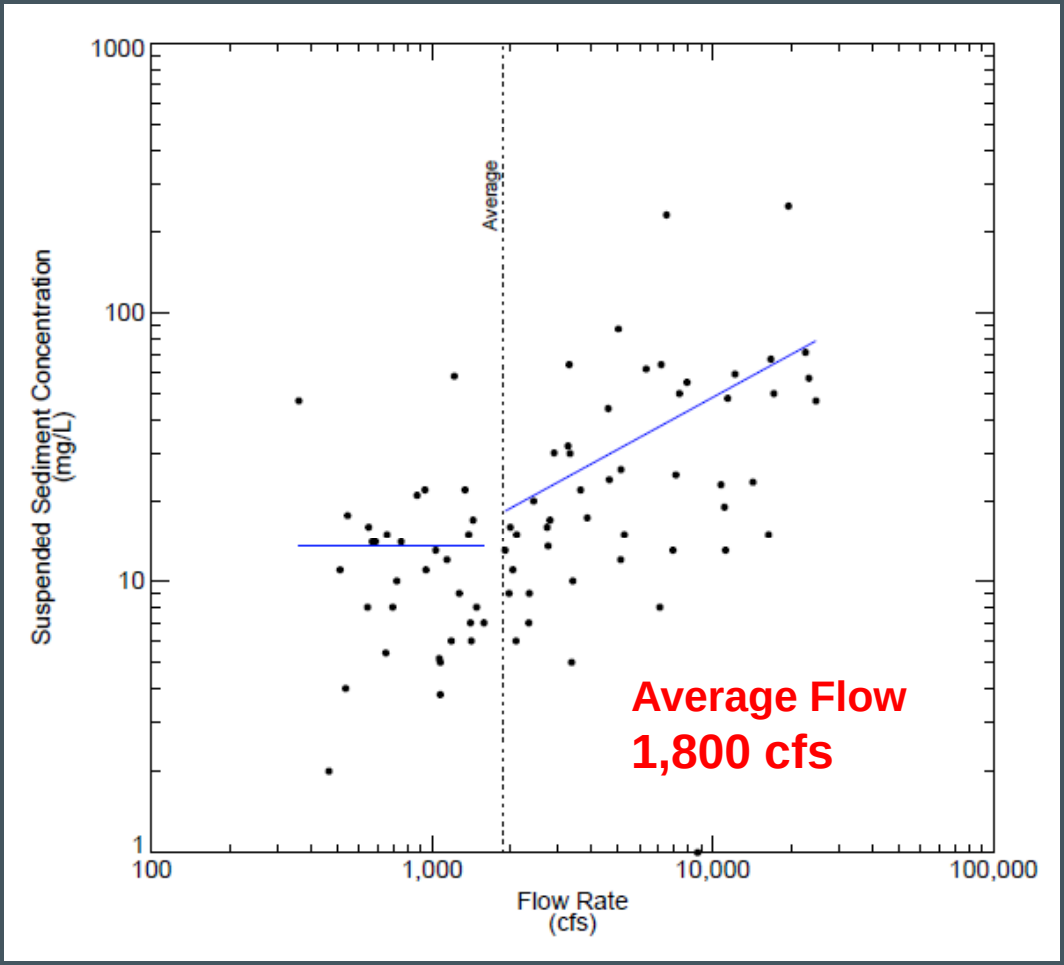
					this transitional behavior on four rivers are shown in the attached PDF: 1) Tittabawassee River (Michigan); 2) Upper Hudson River (New York); 3) Hoosic River (New York); and 4) Lower Willamette River (Oregon). This characteristic of a transition in sediment loading behavior at approximately one to two times the average flow rate, which is observed on many river systems, indicates that water-column turbulence levels begin to significantly increase as discharge becomes greater than approximately the average discharge. This observed behavior in rivers provides support for assuming that flow rates which are about five times greater than the average value being representative of high-flow conditions.
4	Section 2.1 Schedule			What is the contingency if the necessary high flow events do not occur in the two month sampling period?	Contingency options (e.g., potentially extending deployment of the ADCP) will be assessed and discussed with USEPA at the end of the two-month deployment period if the necessary high-flow events do not occur. However, it is reasonably likely that the requisite high-flow events will occur during the planned monitoring period, based on a review of historical flow rate data collected at Lake Houston Dam.
5	Section 2.2.2 Location Positioning			What is the rationale for the location of the 2011 ADCP?	The ADCP is located in a section of river proximal to both the impoundments, the various sampling locations of the upstream sediment load study and in a relatively protected area of the main river channel, while being representative of general flow conditions. This area was also selected because the sediment bed is relatively flat, which is needed for proper operation of the ADCP. The ADCP will measure the magnitude and direction of currents throughout the water column (i.e., vertical velocity profile). A depth-averaged current velocity (magnitude and direction) will also be determined. In addition, the CTD will measure water depth (tidal elevation), temperature, and salinity.
6	Section 2.2.2 Location Positioning			How does having one 2011 ADCP location for the purpose of velocity calibration affect the entire model domain? Would additional 2011 ADCP locations enhance model calibration?	The hydrodynamic model will be calibrated and validated using current velocity data collected at two different locations during two different years (2010 and 2011). These data will be sufficient to adequately calibrate and validate the model.

Sediment Load Rating Curve
Tittabawassee River (Michigan)



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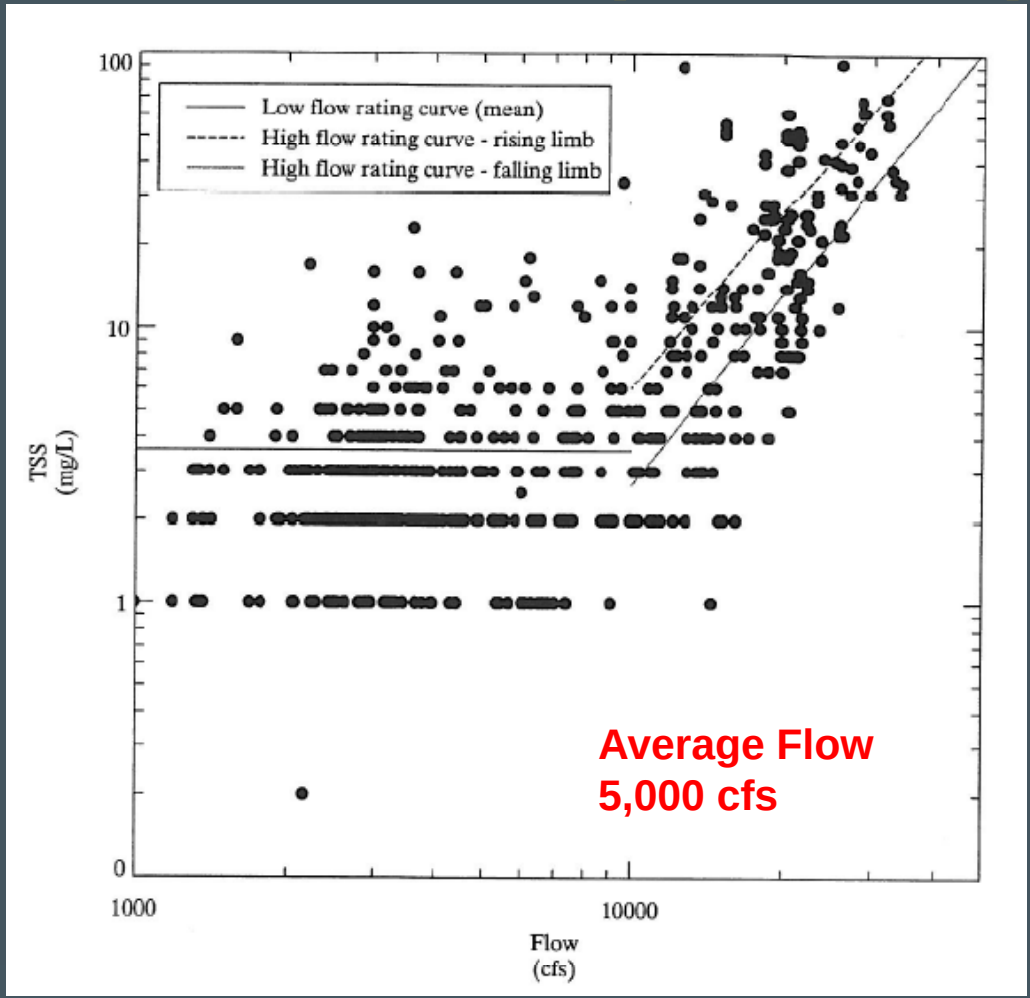
Sediment Load Rating Curve
Upper Hudson River (New York)



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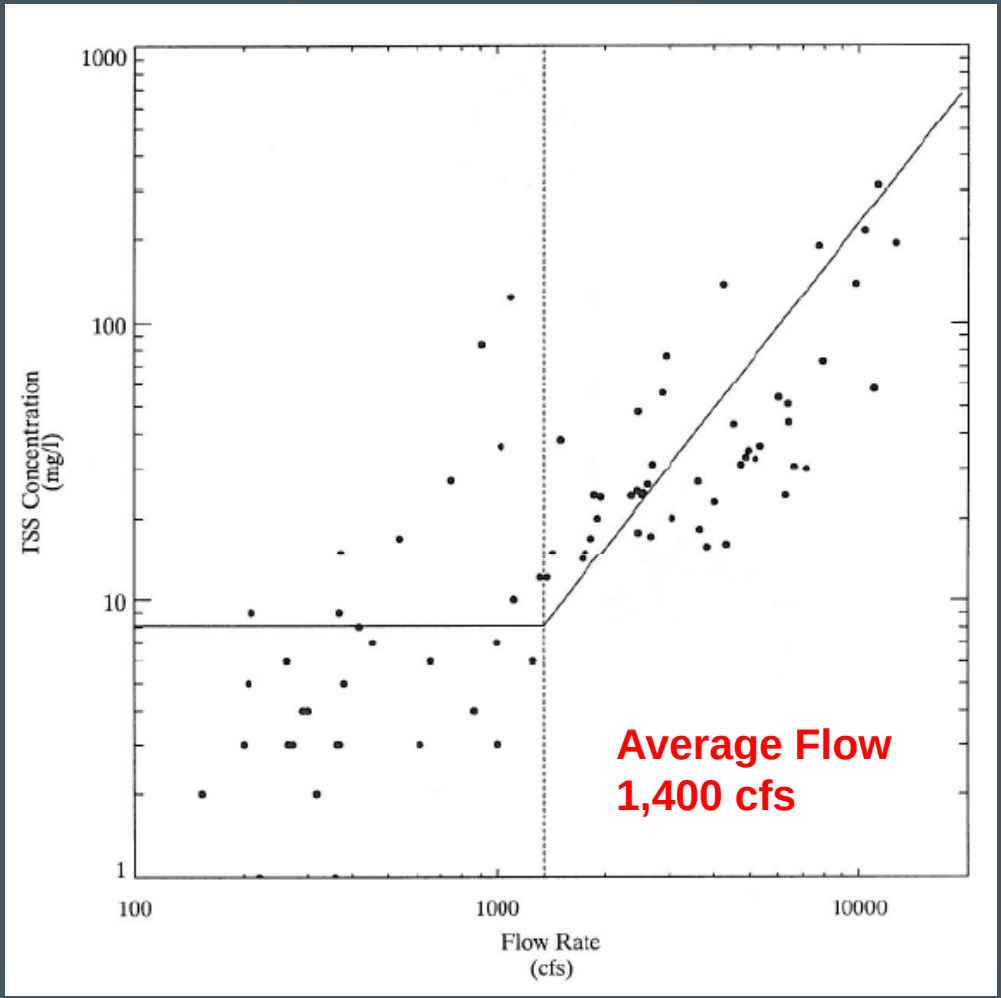
Sediment Load Rating Curve
Hoosic River (New York)



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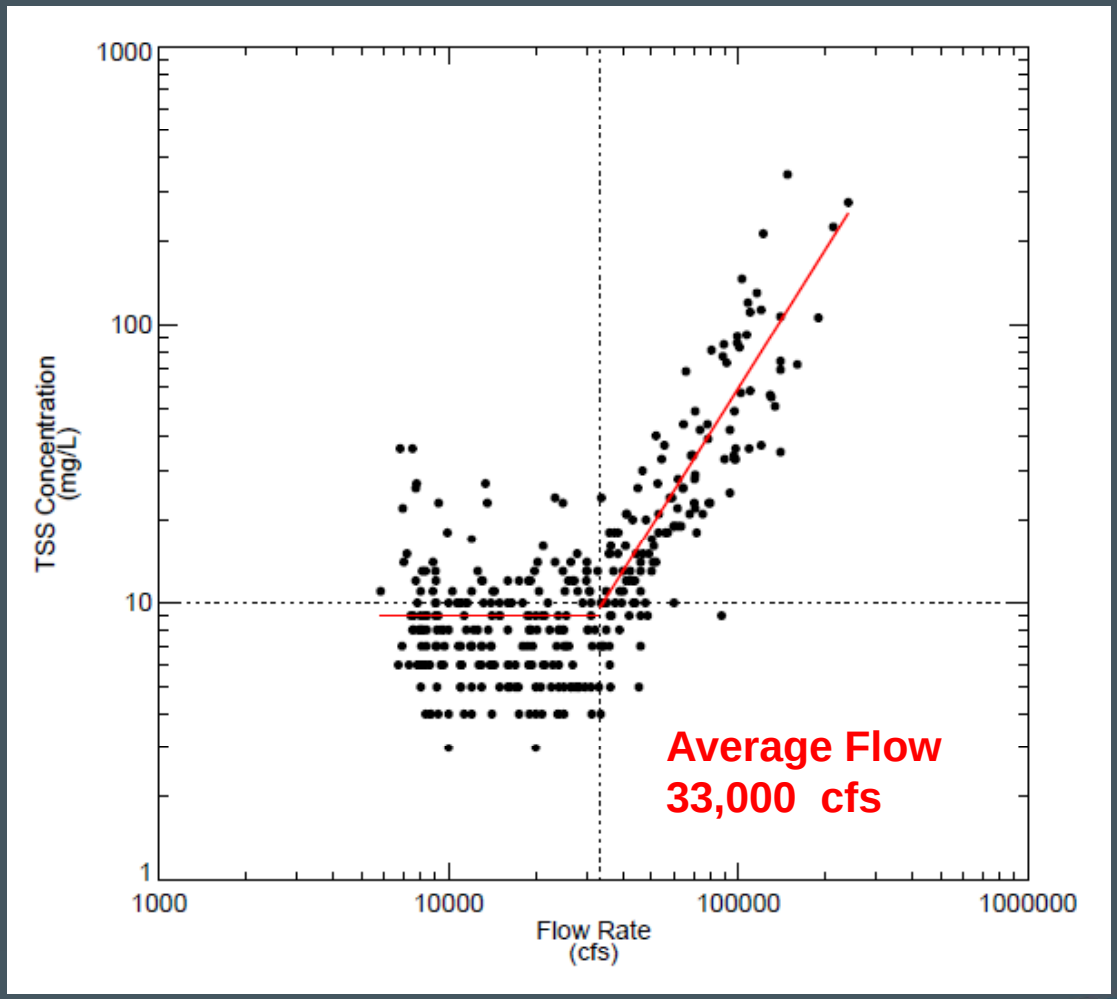
Sediment Load Rating Curve
Willamette River (Oregon)



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