

WATER QUALITY MONITORING
FIELD MANUAL

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INTRODUCTION

The St. Johns River Water Management District currently conducts water quality monitoring programs throughout the District. To ensure consistent and accurate data collection in these programs, sampling personnel must be well versed in water quality monitoring field techniques. A program of "hands on" instruction, reference manuals, and periodic testing has been established to train sampling personnel.

This manual provides a reference for proper procedures in collecting water quality data. Techniques for making instrument measurements, calibrating instruments, collecting water samples, recording data, and quality control are described. Methods for measuring groundwater levels are also included.

DATA HANDLING

Careful data handling is an essential part of water quality monitoring. Samples which are collected properly are useless if the station number and conditions are recorded inaccurately. It does no good to calibrate and use an instrument properly if the information is recorded incorrectly.

Record information on the data forms or in the field notebook in a clear, legible hand. These forms are submitted directly to the data entry operator for storage in the computer, so handwriting errors may be transferred to the computer. Copies of all data forms are retained in the laboratory files as part of the quality assurance program.

Field Sheet

The primary data form for surface water quality sampling is the Field Sheet (Figure 1). This form records data collected by field instruments and observations regarding weather. In the upper left hand corner, record your name, the date, the project number, and check whether or not you have completed a Field Calibration Check Sheet. In the upper right hand corner, record weather conditions as numbers. To determine the weather code which applies to the first two columns, pick a number from the bottom right hand corner (ex. 90 = thunderstorms) which matches the current weather conditions. If it is clear, record #20 (none), meaning no rain.

In the center of the page, record readings from the various instruments. The sample number is a 14 digit code made up of three to four letters, the date and time. The four letters are composed of a three letter station name and comment code (Table 1). The station name is assigned by the project manager and recorded in the computer data base. The date is recorded using six digits for year, month, and day (ex. 810506). The time is recorded as four digits on a 24 hour clock. Each sample number must be unique, therefore, readings that are taken at the same station at different depths are separated by one minute.

The comment code (4th letter) can be used to signify depth in water quality profiles, or it can signify a type of sample such as rainfall or sediment. An X, as a comment code, signifies a grab sample which was collected near, but not at, the regular station. A more exact description of location should be recorded on the back of the field sheet after checking the additional information box on the front. A grab sample is collected to monitor interesting phenomena such as algae blooms or agricultural pumps which are near regular stations, but not normally sampled.

In the bottom left hand corner of the field sheet, check one sample code. If the sample code, date, project number, or weather change, start a new field sheet.

NAME _____

DATE _____

PROJECT # _____

FIELD QC COMPLETE _____

Figure 1

FIELD SHEET

Weather *	Weather Past 24 hours *	Temp. Air (°C)	Cloud Cover (%)	Wind Direction (°)	Wind Velocity (MPH)
41	39	20	32	36	35



Additional information on back of page.

SAMPLE NUMBER	Depth of Collection (M)	Depth of Stream (M)	Temp Water (°C)	Cond Field (umhos/cm)	pH (STD unit)	Redox ORP (MV)	DO Probe (Mg/l)	SAL (PPTH)	SECCHI (IN)	Turb (FTU)	Flow (CFS)
Station Name, Date, Time 98	198	10	94	400	90	299	480	77	76	61	

Check Sample Code
 Fresh
 Brackish
 Sea

Ground
 Rain
 Sediment

Time
 High Tide _____
 Low Tide _____
 Tide Stage (67) _____

*Weather Code: (20) None (54) Moderate drizzle
 (64) Moderate Rain (66) Heavy Rain
 (80) Scattered Showers (90) Thunderstorm

TABLE 1

COMMENT CODE

A	.5 m or less	R	Rainfall sample
B	1.0 m	S	Sediment sample
C	1.5 m	T	
D	2.0 m	U	Unspecified depth code, usually feet
E	2.5 m	V	
F	3.0 m	W	
G	3.5 m	X	Grab sample, approximate station
H	4.0 m	Y	
I	4.5 m	Z	USGS Cooperative sample
J	5.0 m		
K	5.5 m		
L	6.0 m		
M	6.5 m		
N	7.0 m		
O	7.5 m		
P	8.0 m		
Q	8.5 m or greater		

Sediment Description Sheet

This form is used to describe sediment samples (Figure 2). In the upper right hand corner, record your name, the date, the project number, and the type of equipment used for collection (Ekman dredge, petite ponar, sediment corer, hand, etc.). In the columns, record the sample, color of sediment, estimated grain size, the composition and other comments. Record an "S" in the comment code position of the sample number. Sediments are examined using sight, touch, and smell. Describe the sediments' appearance, feel, and odor.

Field Notebook

For surface water data collection, the field notebook is the place to record general observations regarding sampling conditions for that day. Record such things as location, equipment, problems, overall weather conditions and personnel. Record factors which may influence water quality such as low water levels, aquatic weed spraying, nearby bird rookeries or marinas, and structure openings or closings.

For ground water data collection, the field notebook serves as the first location to record all field observations, calculations, and data. It is used as a backup data repository. Each technician should have his or her own notebook to record all observations made. After observations are recorded in the field notebook, data are transferred to computer forms in the field or office to facilitate data entry.

INSTRUMENT MEASUREMENTS

The primary instruments used by the District include:

Hydrolab System 4000

YSI Model 57 Dissolved Oxygen Meter

YSI Model 33 or Fisher Salinity-Conductivity-Temperature
Meter

Cole-Parmer Digisense or Fisher pH Meter

These instruments are sensitive scientific equipment.

Although designed for field use, they should be gently used and protected from damage. The procedure for calibrating and using each instrument varies, however, there are general rules to follow:

1. Allow sufficient warm-up time of instrument electronics before attempting to calibrate or take measurements with the instrument.
2. Once the equipment has been calibrated, try to maintain and operate it under the same conditions. Leave the instrument on if possible. Severe shocks, probe disconnections, or abrupt condition changes will require recalibration.
3. Field instruments generally operate from a battery power source. Weak batteries may give unreliable readings. Make sure batteries have sufficient charge to perform anticipated tasks and take spares when possible.
4. Before making field measurements, allow the probe to equilibrate with its surroundings. Leave the probes in

the water long enough for temperatures to stabilize and accurately reflect water conditions.

The following sections give general information about each instrument. For detailed description, refer to the instruction manual for that particular instrument.

Hydrolab

The Hydrolab 4000 is a multi-parameter instrument which measures dissolved oxygen, conductivity, pH, and temperature. The instrument consists of a sonde which contains the probes, cable, surface unit and battery pack (Figure 3). Instructions for the calibration, use, and care of the Hydrolab are contained in Appendix A.

The Hydrolab is primarily designed for use in fresh water systems. Dissolved oxygen measurements in brackish or marine systems require correction. To correct dissolved oxygen readings, follow the conductivity reading on Figure 4 to the approximate temperature and determine the DO correction factor. Multiply the measured DO by the factor and record.

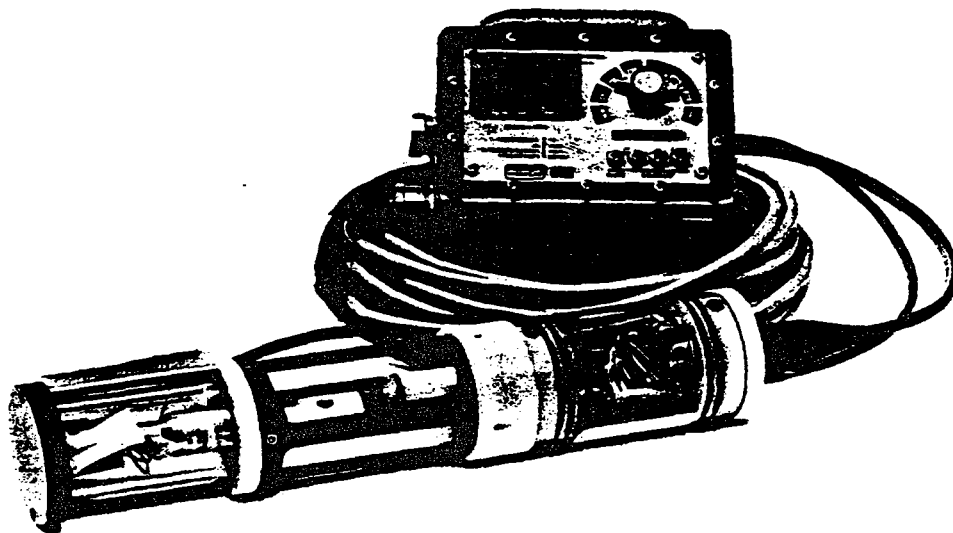
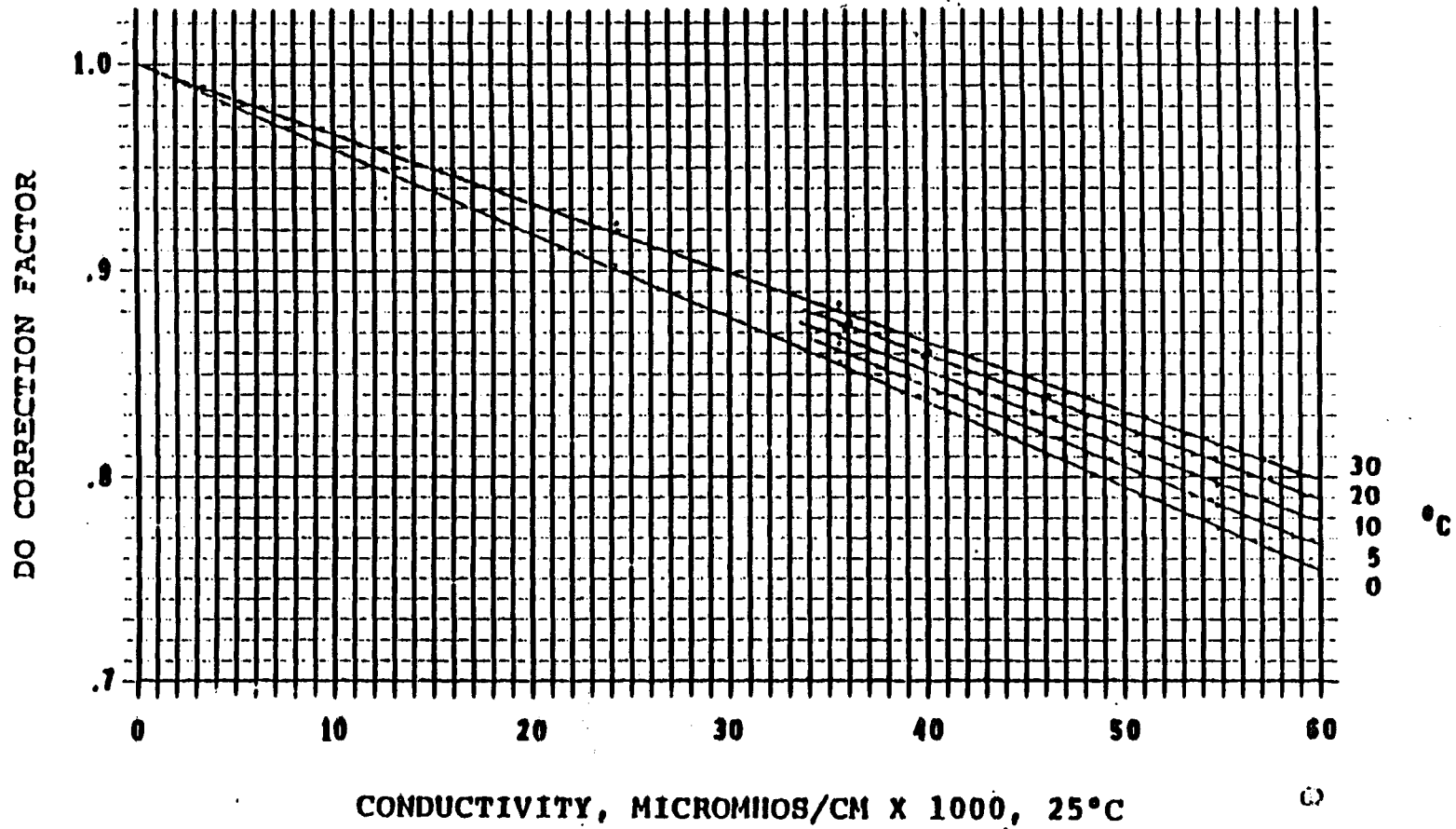


Figure 3

FIGURE 4



SALINITY CORRECTION FACTOR FOR DO vs. CONDUCTIVITY

00000000

YSI Dissolved Oxygen Meter

The YSI Model 57 meter is used for dissolved oxygen and temperature measurements. The instrument consists of a probe, cable, and instrument case (Figure 5). Two different types of probes are available -- a self-stirring probe and a non-stirring probe. In a slow moving stream, agitate the non-stirring probe when readings are taken. The probe should be kept in a moist, not soaked, environment and should not be allowed to dry out. Place a small piece of moist towel in the bottomless plastic bottle provided and insert the probe into the open end.

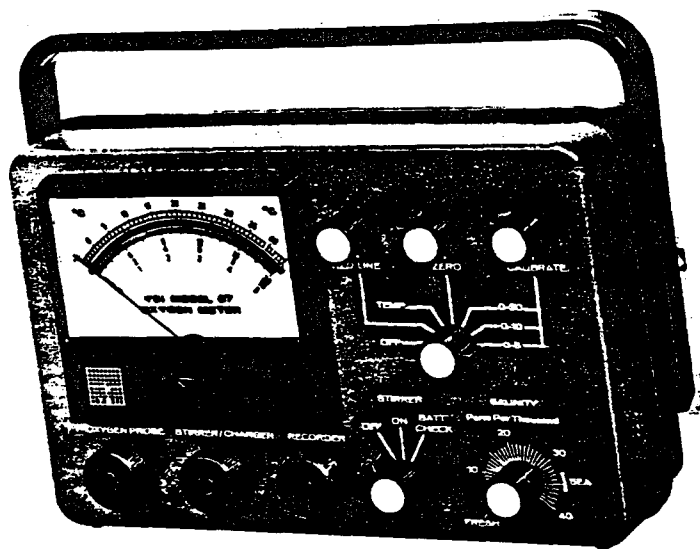


Figure 5

The probe is covered by a thin membrane which must be periodically changed. This membrane should be changed monthly or whenever the probe has dried out, has bubbles or wrinkles, or has been soaking in water for a long period of time. To change the membrane, follow these steps:

1. Unscrew sensor guard or self-stirring apparatus.

2. Remove rubber "O" ring and membrane. Discard membrane but save "O" ring.
3. Grasp probe with your left hand, add electrolyte (KCL solution) until a large meniscus covers the probe tip.
4. Place a new membrane over the probe tip. Avoid trapping bubbles under the membrane.
5. Place the "O" ring over the membrane and gently, evenly roll the "O" ring down the sides of the probe using all fingers, until it seats.
6. Minor wrinkles can be eliminated by gently pulling the membrane edges. If bubbles or permanent wrinkles appear, remove the membrane and begin again.
7. Trim off excess membrane. Check that the steel temperature sensor is not covered by excess membrane.
8. Replace the sensor guard or self-stirring apparatus.

Directions for the calibration and use of the DO meter are contained in Appendix B and are summarized on the back of the instrument case. The instrument should be air calibrated, using the calibration chamber when available. For Florida, assume an altitude or atmospheric correction factor of 1. Chemicals needed to calibrate the instrument using a Winkler Titration are also available.

YSI Model 33 Salinity Meter

The YSI Salinity Meter is capable of measuring salinity, conductivity and temperature. The instrument consists of a probe with 10 meter attached cable and instrument case (Figure 6).

Conductivity varies with temperature. To permit comparison of conductivity measurements made at different temperatures, readings are manually or automatically corrected to a standard temperature of 25°C. Conductivity readings on the YSI Model 33 must be manually corrected; therefore, always record temperature when making conductivity measurements. Instructions for operating the instrument are on the front of the case.

To calibrate the instrument, place the probe in a standard conductivity solution. Multiply the instrument reading by the correction factor for converting non-temperature compensated conductivity values to conductivity at 25°C listed on the back of the meter. The corrected instrument reading should match the standard solution within 1.5% at 25°C.



Figure 6

The probe requires periodic cleaning when used in areas with hard water deposits, oil or organic matter. A dirty probe is indicated when cell test readings cause the measurement to fluctuate by more than 2 percent. To clean the probe, soak it in a cleaning solution available from the laboratory. If cleaning

does not restore probe performance, return it to the laboratory for replatinizing. When making measurements with the probe, allow at least two inches of clearance from non-metallic underwater objects or six inches from metallic objects. Gentle agitation by raising and lowering the probe improves temperature response and sample flow through the probe.

Fisher Conductivity Meter

The Fisher Conductivity Meter is capable of measuring salinity, conductivity (uncorrected for temperature and corrected to 25°C) and temperature. The instrument consists of a meter case and probe with a short lead. Instructions for operating the instrument are in the case lid. To calibrate the instrument, place the probe in a standard conductivity solution. Dip probe up and down in the solution to expel any trapped air. Turn the meter on, unlock the Standardize control knob and allow the probe to equilibrate. Using the corrected conductivity (λ_{25}) function, adjust the Standardize control to the known value of the standard solution and lock the Standardize control knob.

Cole-Parmer Digisense pH Meter or Fisher Accumet pH Meter

The portable pH meter is designed to measure pH values ranging from 0-14. The instrument consists of a meter and electrode with a lead (Figure 7).

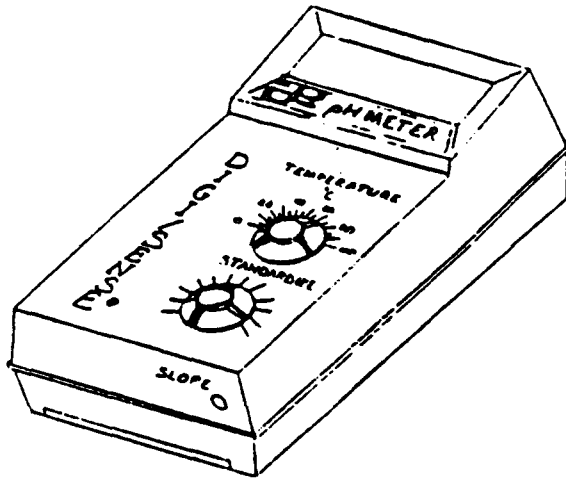


Figure 7

To set-up the meter, connect the probe to the instrument. Do not turn the instrument on without the probe connected or immersed in liquid. To prevent electric charges from building up on the probe, do not wipe the probe, blot it dry.

To standardize or calibrate the instrument, follow these steps:

1. Rinse the pH probe with distilled water and blot dry with a Kimwipe.
2. Immerse the probe in a pH 7.0 buffer solution.
3. Take the temperature of the buffer solution using a clean thermometer which has stabilized.
4. Set the TEMP°C control to the temperature read.
5. Adjust SLOPE control fully clockwise (this should already be set).
6. Turn the BATT FWR switch on.

7. Operate the STANDARDIZE control to cause the display to indicate the pH of the buffer solution.
8. Remove the probe from the buffer solution.
9. Repeat steps 1-8 with a pH 4 or pH 10 buffer, adjusting the slope control to indicate the pH of the second buffer solution.
10. Repeat steps 1-8 and recheck the pH 7 buffer.
11. Turn the BATT PWR switch off.

pH measurements of samples are made the same as when calibrating. Temperature readings can be obtained from other instruments such as the D.O. or S-C-T meters. Make sure sample depth is sufficient to cover the pH probe. A BATT LOW display instead of a digital readout indicates the batteries need to be replaced.

SURFACE WATER FIELD EQUIPMENT

Other equipment is used in water quality monitoring besides the previously described instruments. This equipment is used to make measurements or collect samples. Although it is more rugged than the electronic instruments, it still requires careful handling and maintenance. Flush the equipment with fresh water after use, especially after use in salt water. Lubricate moving parts to prevent freeze-up and corrosion.

The following sections describe each piece of equipment and how to use it.

Secchi Disk

The secchi disk is a circular plate with the upper surface divided into quadrants, two black and two white. It is used to estimate the transparency of water. Lower the disk into the water on a graduated line measuring the depth at which it disappears and reappears. Record the average of the two measurements to the nearest inch. Try to use the secchi disk between 9:00 a.m. and 4:00 p.m.

Van Dorn Sampling bottle

The Van Dorn sampler is designed to collect water samples at specific depths or other areas inaccessible by hand. The sampler consists of a PVC tube sealed by Neoprene end caps released through a tripping mechanism (Figure 8), a cable, and messenger. This particular sampler collects water samples horizontally through the water column.

To operate the sampler, cock the end caps open by attaching the cables to the tripping mechanism. Close all valves. Lower the sampler while retaining the messenger. At the desired depth, move the sampler up and down gently to rinse with ambient water. Release the messenger and raise the sampler after the end caps have closed. To discharge water from the sampler, push in and turn the black valve then open the yellow bleeder valve.

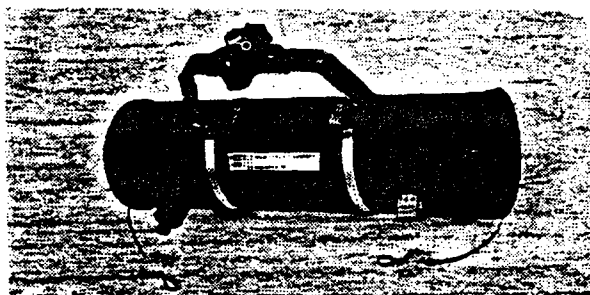


Figure 8

Ekman Dredge

This is designed to collect bottom samples of benthic fauna or sediments. The dredge consists of a sample chamber with spring-closed jaws, cable, and messenger (Figure 9). The messenger is a brass-plated weight attached to the cable, which when released, travels down the cable striking the tripping mechanism and closing the jaws.

To operate the dredge, open the jaws by attaching the cables to the tripping mechanism. Make sure the cables are firmly attached and be extremely careful with fingers and hands around the jaws. Retain the messenger while lowering the dredge to the bottom. Once the chamber is seated, try to keep the cable as vertical as possible and release the messenger. After the jaws have closed (signified by noise and possibly gas bubbles), gently tug the dredge free of the sediment and raise to the surface. Open the jaws to discharge the sample.

The petite ponar dredge may be substituted for the Ekman dredge depending on the type of bottom to be sampled. The advantages to using the Ekman dredge include its lightness and flaps instead of mesh which minimize pressure waves and washout.

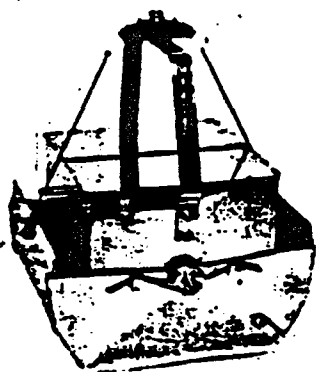
Petite Ponar Dredge

This dredge is designed to collect samples of benthic fauna. The dredge consists of a sampling chamber covered by brass mesh screen and attached to a cable (Figure 9).

To operate the dredge, first remove the safety pin from the sliding latch. Cock the jaws open by sliding the latch until the instrument weight can be suspended from the cable without the jaws closing. Lower the dredge to the bottom until it is seated. Jerk the cable upward to trip the jaws, then slowly raise to the surface. This dredge does not have a messenger.

To discharge sample from the chamber, push down on the latch until the jaws open. Be careful with fingers and hands around the dredge jaws.

EKMAN



PETITE PONAR

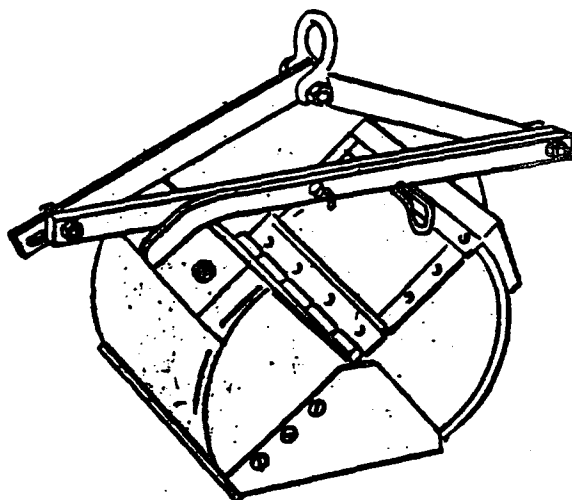


Figure 9

Peristaltic Pump and Filter

For certain parameters such as dissolved metals or nutrients, analyses are performed on a filtered sample rather than a whole water sample. Filtrations are performed in the field using a portable filtration unit. The unit consists of a peristaltic pump and 142 mm membrane filter holder. Power is supplied using a cord clipped to the boat or car battery terminals. To collect filtered samples, follow the steps described below:

1. Assemble filter holder. Connect pump tubing to holder. Plug in pump power supply cord and attach to battery terminals.

2. Change membrane filter before each sample.
3. Place intake tubing in distilled water container. Flush tubing and filter with distilled water. Remove tubing from distilled water with pump running to drain distilled water from tubing.
4. Place intake tubing in sample (bottle or surface water body). Flush tubing and filter with sample. Run enough sample water through tubing to push out any remaining distilled water.
5. Rinse sample bottle and cap. Collect sample.
6. Remove tubing from sample water with pump running to drain sample water from tubing.

GROUND WATER FIELD EQUIPMENT

Water Level Measurements

Water level measurements are basic for all hydrologic investigations. Water level measurements are used to determine directions of ground water flow, define hydrologic characteristics of aquifers, evaluate stresses on the aquifer, and determine areas of recharge and discharge. There are numerous other uses of ground water level measurements which will not be mentioned here.

Once it has been determined that a water level measurement is to be taken at a particular well, there are several techniques which may be used depending on the well type. These are:

- I. Non-flowing Wells
 - A. Graduated steel tape
 - B. Electrical
 - C. Air line methods
- II. Flowing Wells
 - A. Low pressure head
 - B. High pressure head
- III. Recording Devices
 - A. Mechanical recorders
 - B. Pressure recorders

(Graduated Steel Tape)

The graduated steel tape method is considered to be the most accurate method for measuring the water level in nonflowing

wells. A black tape is better than a chromium-plated tape. A slender weight, usually made of lead, is attached to the ring at the end of the tape to insure plumbness and to permit some feel for obstructions. Lead weights are used so that if the weight should fall off the tape in a pumped well, the soft lead would be less likely to damage the pump. The weight is attached in such a way that if the weight becomes lodged in the well, the tape can still be pulled free. Attach the weight with wire strong enough to hold the weight but not as strong as the tape.

The lower few feet of tape is chalked by pulling the tape across a piece of blue carpenter's chalk. The wet chalk mark identifies the portion of the tape that was submerged. Lower the graduated steel tape from the measuring point at the top of the well until a short length of the tape is submerged. The weight and tape should be lowered into the water slowly to prevent splashing. Submergence of the weight and tape may temporarily cause a water level rise in wells or piezometers having very small diameters. This effect can be significant if the well is in materials of very low hydraulic conductivity. Under dry surface conditions, it may be desirable to pull the tape from the well by hand, being careful not to allow it to become kinked, and reading the water mark before rewinding the tape onto the reel. In this way, the water mark on the chalked part of the tape is rapidly brought to the surface before the wetted part of the tape dries. Read the tape at the measuring point for the well, and then read the water mark on the tape. The difference between

these two readings is the depth to water below the measuring point.

As a standard of good practice, the observer should make two measurements. If two measurements of static water level made within a few minutes do not agree within about 0.01 or 0.02 foot, continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable. Where water is dripping into the hole or covering its wall, it may be impossible to get a good water mark on the chalked tape.

Unless the well is equipped with an access pipe that is placed to eliminate the possibility of lowering the tape into the pump impellers, the graduated-tape methods should not be used to measure pumping levels in a well.

In some pumped wells, a layer of oil floats on the water. If the oil layer is only a foot or so thick, read the tape at the top of the oil mark and use this data for the water-level measurement. The measurement will not be greatly in error because the oil surface in this case will differ only slightly from the water level that would be measured if the oil was not present. If several feet of oil are present in the well, or if it is necessary to know the thickness of the oil layer, a water-detector paste for detecting water in oil and gasoline storage tanks is available commercially. The paste is applied to the lower end of the tape that is submerged in the well. It will show the top of the oil as a wet line and the top of the water as a distinct color change.

After each well measurement, that part of the tape measure that was wetted should be disinfected to avoid contamination of other wells.

(Electrical Instruments)

Many types of electrical instruments have been devised for measuring water levels; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Some instruments consist of a single conductor that is lowered into the well where the metal well casing is used as the second conductor. More commonly, a two-conductor cable and special probe are used. Various forms of electrolytic cells using two electrodes of dissimilar metals have been used, but current is more commonly supplied by batteries.

The District uses a two-conductor tape, 300 feet long. The electrical tape is marked at 5 foot intervals with clamped-on bands. A string of weights below the contacts keeps the tape taut. Completion of the circuit is indicated by a deflection of the needle on the reel.

Before lowering the probe in the well, the circuitry can be checked by dipping the probe in water and observing the indicator. It may be necessary to scrape the electrical contacts clean from time to time to get rid of surface oxidation and get a good electrical contact with the water. The probe should be lowered slowly into the well until contact with the water surface is indicated. The electric tape is marked at the measuring point and partly withdrawn; the distance from the mark to the nearest

tape band is measured and added to (or subtracted from) the band reading to obtain the depth to water. It is good practice to check by taking a second or third reading before withdrawing the electric tape from the well. Independent electric tape measurements of static water levels using the same tape should agree to within ± 0.04 feet.

The tape should not rub across the top of the casing while lowering or raising because the metal bands can become displaced; consequently, placement of the bands should be checked yearly with a steel tape.

Electric tapes are more cumbersome and inconvenient to use than the wetted-tape method, and they normally give less accurate results. In some situations, however, they are superior. Where water is dripping into the hole or covering its walls, it may be impossible to get a good water mark on the chalked tape. In wells that are being pumped, particularly with large-discharge pumps, the splashing of the water surface makes consistent results by the wetted-tape method impossible. Where a series of measurements are needed in quick succession, such as in pumping tests, electric tapes have the advantage of not having to be removed from the well for each reading. Electric tapes are also safer to use in pumping wells because the water is sensed as soon as the probe reaches the water surface and there is less danger of lowering the tape into the pump impellers.

In pumped wells having a layer of oil floating on the water, the electric tape will not respond to the oil surface and, thus,

the fluid level determined will be different than would be determined by a steel tape. The difference depends on how much oil is floating on the water. A miniature float-driven switch can be put on a two-conductor electric tape that permits detection of the surface of the uppermost fluid. The electric tape should be disinfected after measurements in each well.

It is especially important to check the electric line length by measuring with a steel tape after the line has been used for a long time or after it has been pulled hard in attempting to free the line. The District's policy is to annually calibrate the electrical tape against a steel tape. The date of calibration and any correction factor will be placed on the sounding reel.

In addition, because the probe is larger in diameter than the wire, the probe can become lodged in a well. Some operators attach the probe by twisting the wires together by hand and using only enough electrical tape to support the weight of the probe. In this manner, the point of probe attachment is the weakest point of the entire line. Should the probe become "hung in the hole," the line may be pulled and breakage will occur at the probe attachment point, allowing the line to be withdrawn.

(Air Line)

The air line method is the least accurate of the methods discussed so far. However, it is especially useful in pumped wells where water turbulence may preclude using more precise methods. A small diameter air-type tube of known length is installed from the surface to a depth below the lowest water level.

expected. Compressed air is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the air line multiplied by 2.31 (feet of water for one psi) equals the length in feet of submerged air line. The depth to water below the center of the pressure gage can be easily calculated by subtracting the length of air line below the water surface from the total length of air line (assuming the air line is essentially straight). Accuracy depends on the precision to which the pressure can be read. The equation to use is as follows:

$$\text{Depth to water} = \text{Total air line length} - (2.31 * \text{air line reading})$$

Since the accuracy is very dependent on the accuracy of the pressure gage, length of air line and its straightness, the overall accuracy of the measurement is poor. The air line method should be the last method used and the reading only recorded to the nearest foot.

When taking an air line measurement, it must be remembered that the air line and any connections to it must be airtight throughout its entire length. If the line is broken or leaky, large errors may occur. A long-term increase in air line pressure may indicate a gradual clogging of the air line. A relatively sudden decrease in air line pressure may indicate a leak or break in the air line. Air line pressures that never go above a constant low value may indicate that the water level has dropped below the outlet orifice of the air line. To minimize

the effect of turbulence, the lower end of the air line should be at least five feet above or below the pump intake.

Flowing Wells

Because the water level in a flowing well is above the land surface, it is necessary to close off the flow in order to measure the static water level or head. Some flowing wells are equipped with valves so that the flow can be shut off, but many are open at the top and flow freely. Such wells can be shut-in by using a soil-pipe test plug, also known as a sanitary seal, which is available from most plumbing supply houses in sizes to fit pipes from 2 to 10 inches in diameter. These plugs consist of a length of small-diameter pipe, generally 3/4 inch, surrounded by a rubber packer that can be expanded by means of an attached wingnut to fit tightly against the inside of the well casing or discharge pipe. The end of the small pipe is threaded for the attachment of a valve, hose, or pressure gage. Shutting off small diameter wells with these plugs, even when the pressure is relatively high, is relatively easy. As a safety precaution against blowouts, large diameter plugs should be clamped to the casing when they are used in high-pressure wells.

A valve or a test plug on a flowing well should be closed and opened gradually. If pressure is applied or released suddenly, the water hammer effect may permanently damage the well by cave-in of the aquifer material, breakage of the casing, or damage to distribution lines or gages. A pressure snubber installed ahead of the gage can reduce the effect of the water hammer. The time

required for the well to reach static pressure after it is shut in is variable, ranging from hours to days. Shut-in time (elapsed time since well was shut-in) long enough to reach true static pressure may be impractical or impossible for some wells. In all cases, the shut-in time should be recorded for each pressure gage reading. Readings should be made frequently starting immediately after shut-in; longer intervals may be used as the shut-in time increases. During subsequent visits to the well, it is desirable to duplicate the previously used shut-in time.

Pressure gages are delicate instruments that can be broken easily and can give wrong readings if dropped or otherwise mishandled. The pressure gage used should be selected so that the anticipated water pressure falls within the middle third of the gage range because if the well pressure exceeds the gage limits, the gage may be ruined. If in doubt, a wide range gage should be used to make an initial estimate of the pressure, followed by use of a gage with the proper range for a more accurate measurement. A pressure gage should not be connected to a well that has a booster pump in the system because if the pump starts, the pressure surge may ruin the gage. In addition, the locations of any check valves should be carefully noted. Connecting the pressure gage to the wrong side of the check valve may give only the reading for a pressure in the distribution line or in a storage tank. The pressure indicated by a gage refers to the pressure at the center of the gage, and this point should therefore be held on a level with the measuring point or at a measurable distance above or below it.

Due to the delicacy of the indicating pressure gages it will be the District's policy to calibrate them quarterly on the test stand in the Field Services Compound. The date of calibration and any correction factors to be used will be placed on each pressure gage. The gages should also be carried around in the field only in the foam lined boxes provided for them.

(Low Pressure Head Measurement)

In flowing wells where the head is only a few feet above the ground, it is often practical and convenient to measure the head directly. A short length of hose can be connected tightly to the well and the free end of the hose is raised until the flow just stops, or a transparent plastic tube in which the water level can be observed directly against a measuring rod can be used. Heads can be measured to an accuracy of 0.01 foot by this method. Again, shut-in times should be recorded as indicated above.

(High Pressure Head Measurement)

Where the static water level is more than 5 or 6 feet above land surface, the foregoing method is generally impractical. The indicating gages may be calibrated to read with feet of water or in pounds per square inch; in either case, they are probably not accurate to within 0.5 feet although they can be read to 0.1 foot. A reading taken by the pressure gage should be recorded only to the nearest 0.1 foot after adding or subtracting from the elevation of the measuring point.

Water Level Recorders

Devices for recording changes in water levels may be mechanical, electronic, or electromechanical. A further distinction is the manner in which the device detects changes. A float or an electromechanically actuated water-seeking probe may be used to detect vertical changes of the water surface in the hole, or a mechanical or electrical pressure gage submerged several feet below the water surface may be used to detect changes in fluid pressure resulting from water level changes. The principal advantage of pressure-sensing devices is that they may be used in packed or otherwise sealed-off zones in a well. In addition, their response to rapid changes of fluid pressure is generally better than that of mechanical devices.

(Mechanical Recorders)

At the present time, the District is utilizing two different types of mechanical recorders. Both types utilize floats mechanically coupled to some type of recording device. The graphical recorders, such as the Stevens F or A-71 recorders record the water level on graph paper. While the Stevens F recorder can be driven by a battery operated clock, it and the A-71 recorders commonly use a spring wound clock. The digital punch recorders, such as the Stevens model 7001 or Fischer-Porter recorders record the water levels as punches on paper tape. The digital recorders operate off of batteries and have electronic timers to actuate the punch cycle.

Where depth to water is more than a few feet below the top of the casing, special care must be taken to minimize friction between the float cable and the walls of the well. The float selected should be the largest diameter that can be accommodated by the casing. In these wells, the largest error is caused by the friction between the float cable and the well casing. Special care should be taken to insure the float cable and float is clear of the well casing. If the clearance between the float and the casing is small, the float cable should be arranged so that the counterweight does not have to pass the float, but is always above or below the water level. When the counterweight is immersed, a little extra weight should be used to counteract the water's buoyancy.

Water level recorders should be protected from the weather and vandalism by a suitable shelter that is solidly anchored. The part of a recorder most susceptible to malfunction is the clock. To insure continuous records, field personnel who visit recorders should carry spare clocks. Malfunctioning clocks should be sent to a reliable clock-repair service for maintenance, and all clocks should be cleaned and adjusted periodically.

During each visit to a recorder installation, the water level should be measured (preferably by the steel tape method) and the measurement compared with the recorded value and the appropriate adjustments made with the recorder.

(Pressure Recorders)

In flowing wells, the District utilizes the Foxboro 8" circular dial recorders. These recorders have the same limitations as the indicating pressure gages. Any valve or test plug on the well with a pressure recorder should be opened and closed gradually to minimize any water hammer effect. A valved tee should be installed in the line connecting the pressure recorder and the well. Using the tee, the pressure recorder should be checked monthly against a pressure gage. Differences should be noted on the chart and the pressure recorder adjusted accordingly. As with a pressure gage, the reading should be recorded to the nearest 0.1 foot after correction to mean sea level. Ideally, the pressure recorder should be sized so that the average reading is in the midpoint of its range.

SAMPLE COLLECTION

Water samples are collected in the field for detailed analysis in the laboratory. The goal of water sampling is to collect a representative sample without contamination and to prevent the sample from changing until it arrives in the laboratory. The theory behind locating sample sites is discussed in the Site Evaluation Section.

Bottles/Containers

Water quality samples are analyzed for a variety of parameters which require different containers to prevent contamination and simplify preservation. For most analyses, samples will be collected in high-density polyethylene bottles. Special samples may require glass bottles, teflon caps, or other specific requirements. The following sample bottles are available from the laboratory:

<u>Label</u>	<u>Size</u>	<u>Preparation</u>	<u>Parameters</u>	<u>Preservative</u>
Blue	1/2 gal. or 8 oz.	None	Minerals, BOD, TOC general sampling	Iced
White Red	Quart 8 oz.	None Hydro- chloric acid wash	Chlorophyll Nutrients	Iced. Iced, 1/2 ml sulfuric acid
Green	4 oz.	Nitric acid wash	Metals (Dissolved)	Iced, 1/2 ml nitric
Yellow	8 oz.	(same as above)	Mercury	(same as above)
Pink	8 oz.	(same as above)	Metals (Total)	(same as above)
Orange	8 oz.	Hydro- chloric acid wash	Dissolved Nutrients	Iced, 1/2 ml sulfuric acid

The bottles are sized so that one bottle is generally sufficient to collect enough sample to analyze for the parameters intended. Therefore, if you are required to sample for nutrients, metals and minerals, collect a red, green, and blue labeled bottle at that site. If you wish to sample for chlorophyll and minerals at another site, collect a white and blue labeled bottle, and so on. Bottles are washed, labeled and capped in the lab. Discard bottles which have lost the cap or label.

Plastic bags are used to store sediment samples or biological samples such as plants or animals. Large wide mouth jars are also used to store biological samples. These containers are not color-coded.

Requests for bottles and equipment should be made at least one week before the planned sample collection. Submit a Field Equipment and Supply Request Form (Figure 10) to the laboratory.

Surface Water Collection Techniques

Water samples will be collected using one of three methods: point sampling, composite sampling, or remote sampling. The majority of the samples collected will be point samples where bottles are filled by hand at .5 meter below the surface. Composite samples are a series of samples collected over time or a distance transect, mixed together in a churn, then poured into sample bottles. Remote samples are collected from automatic samplers or sample bottles attached to a line. Remote samples

FIELD EQUIPMENT AND SUPPLY REQUEST FORM

Name _____ Date Equipment Required _____

Project # _____ Expected Date of Return _____

Date _____ * Please notify lab if equipment cannot be returned on time.

Equipment Rcvd by _____ Equipment Returned to _____

Date Received _____ Date Returned _____

Sample Bottles (Please specify quantity)

_____ Mineral, 1/2 gal, blue label	_____ Nutrients, Total, 8 oz, Red label
_____ Mineral, 8 oz, blue label	_____ Nutrients, Dis, 8 oz, Orange label
_____ Metal, Dis, 4 oz, green label	_____ Chlorophyll, 1 qt, white label
_____ Metals, Total, 8 oz, pink label	_____ Purgeables, 40ml, white label
_____ Mercury, 8 oz, yellow label	

Equipment (Please specify quantity)

_____ pH Meter	_____ Hydrolab	_____ Filtration Unit
_____ Cond. Meter	_____ Tool Box	_____ Secchi Disk
_____ D.O. Meter	_____ Thermometer	_____ Flow Meter
_____ Coolers		_____ Van Dorn Sampler

Supplies (Please check requested items)

_____ pH Buffers	_____ Sulfuric acid	_____ kim wipes
_____ Cond Std	_____ Nitric acid	_____ gloves
_____ Alkalinity Reagent	_____ DI Water	_____ pipets
_____ filters (47mm)	_____ DO Probe kit	_____ droppers
_____ filters (142mm)	_____ Plastic Bags	_____ EPA Sample seals

Additional items requested _____

are usually collected from bridges or at depths greater than arm's length.

Regardless of the method used, the same general precautions should be taken. Avoid stirring up the bottom at the sample site. If bottom sediments are stirred up, give them time to settle before collecting samples and note the condition in the field notebook. Write the 14 digit sample number on the bottle label before immersing it in the water. Use a permanent marking pen for labeling. Rinse sample bottles and caps with ambient water before collecting the sample.

Sediment samples may be collected with a variety of devices, including the Ekman Dredge, the Petite Ponar Grab, a corer, or by hand. Collect sediment samples after water samples and measurements are collected. In order to assure a representative sample, collect three samples, usually from the front and both sides of a boat. Mix these samples together in a bucket and fill a sample bag. Squeeze excess air from the bag and attach label tags.

Ground Water Collection Techniques

The ground water environment differs drastically from the surface water environment. The velocity of surface waters is commonly measured in kilometers or miles per hour and the flow is sometimes turbulent. Surface waters are generally at, or close to, equilibrium with the air temperature or pressure. They are exposed to light and contain oxygen and abundant organisms.

Ground water flow is generally slow moving and laminar. It is not exposed to light and is often without oxygen. Lastly, it

is frequently at a different temperature and pressure than that at the surface above it.

When ground waters are being sampled for their chemical constituents, the hydrologist's aim is to collect a representative sample of the aquifer. In order to do this, the integrity of the sample should be preserved during collection. Alternatively, it could be quickly obtained and preserved before significant changes occur or be allowed to change in a known manner.

Collection of representative groundwater samples may be difficult. Many wells, and observation wells in particular, do not commonly have a pump. Consequently, water stands in the well casing and becomes stagnant. While standing in the casing, it degasses, changes in temperature, pH, and other physical and chemical parameters. Contaminants can be introduced from the surface or through leaching, oxidation or reduction of the well casing. A good example would be high levels of iron found in the casing water of a steel cased well due to oxidation.

For these reasons ground water sampling must be handled in a different manner than surface water sampling. Once the sample has been collected, the procedures for instrument measurements, preservation and laboratory requests will remain the same.

(Flowing Wells)

If the well to be sampled is a flowing well, it must be determined whether or not the water in the casing is stagnant or fresh. If the well is uncontrolled, it can be safely assumed to be representative of the aquifer and samples immediately taken.

If the well is valved, it must be determined when "fresh" water is being sampled. Turn the well on and let some or all of the water flow into a bucket or other catchment device. Monitor the temperature and conductivity of the water. When both values have remained stable for 5 to 10 minutes, it can be assumed that the casing has been flushed and ground water that is representative of the aquifer is now reaching the well head. A good rule of thumb is to remove a volume of water from the well before sampling equal to five times the volume of water in the casing. Table 2 and Appendix C can be used to estimate the minimum water volume and time required to pump a well before sampling.

(Pumped Wells)

A well with a pump can be treated as a flowing well, providing of course, you can run the pump to take a sample. If you are not sure a running pump is pulling representative water from the aquifer, spend a few minutes monitoring the temperature and conductivity of the water being pumped before sampling. If you have to turn the pump on, use the same steps as described above for a valved flowing well.

(Wells Without Pumps)

The majority of wells used for ground water monitoring will not have pumps. Water will have to be removed from the well by a variety of methods depending upon the size of the well, equipment available, and the type of chemical analysis to be performed on the sample. Common methods of removing a sample from a well are hand bailers, centrifugal pumps, submersible pumps, peristaltic

TABLE 2 : ESTIMATED MINIMUM WATER VOLUME TO REMOVE BEFORE SAMPLING A WELL

CASING	1" I D	1.25" I D	2" I D	3" I D	4" I D	6" I D	8" I D	10" I D	12" I D	18" I D
WATER VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5	VOLUME X 5
5	1	1	4	9	16	36	65	191	144	339
19	2	3	6	18	32	73	139	293	293	669
29	4	6	16	36	65	146	269	497	597	1,321
39	6	9	24	54	97	229	391	611	881	1,982
49	8	12	32	73	139	293	521	815	1,174	2,543
59	10	15	48	91	162	367	652	1,019	1,466	3,394
69	12	19	48	189	195	449	782	1,223	1,762	3,365
79	14	22	57	128	227	514	912	1,427	2,056	4,626
89	16	25	65	146	269	587	1,043	1,631	2,349	5,287
99	18	28	73	164	292	669	1,173	1,835	2,643	5,748
109	20	31	81	183	325	734	1,304	2,039	2,937	6,699
119	40	63	163	366	659	1,469	2,659	4,979	5,874	13,213
129	60	95	244	549	976	2,293	3,912	6,119	8,912	19,528
139	81	126	326	733	1,391	2,937	5,216	8,159	11,749	26,437
149	101	158	407	916	1,627	3,671	6,521	10,198	14,687	33,846
159	121	199	489	1,099	1,952	4,406	7,825	12,238	17,624	39,656
169	142	222	579	1,283	2,278	5,140	9,129	14,278	20,562	46,265
179	162	253	652	1,466	2,603	5,874	10,433	16,318	23,499	52,874
189	182	285	733	1,649	2,929	6,609	11,738	18,358	26,437	59,484
1,000	233	317	815	1,832	3,254	7,043	13,042	20,577	27,911	60,873

In order to estimate the amount of water and the time necessary to evacuate a well to get a representative aquifer sample take the following steps; 1) estimate the length of the water column in the casing; 2) follow that row across until the column with the proper well diameter is reached; 3) use the volume in gallons and divide by the pump capacity in gallons per minute; 4) the resulting time in minutes will be the necessary minimum time required to evacuate the well casing to get a representative sample.

pumps, boat bailers, compressed gas pumps and many, many more. Each type of device has its limitations and advantages which will not be discussed here.

In order to properly sample the well to get a good representative sample of the water in the aquifer, it will be necessary to remove the water standing in the well casing. Again, a good rule of thumb to use is to remove a volume of water equal to five times the volume of water in the well casing. Use Table 2 to estimate the time required to pump a well before sampling. Alternately the temperature and specific conductivity of the water can be monitored until it stabilizes.

Preservation

Samples should be preserved in the field at the time of collection or as soon as possible thereafter. Add the suggested amount of preservative using a precise volume dispensing bottle or pipet. Preserving with acid causes bacterial and algal activity to cease, provided the pH of the sample is lowered below 2. To check if samples have been properly preserved, randomly test 5% of the samples with litmus paper. The pH should be between 1.5 and 2. To prevent contamination of the sample with impure acid, obtain fresh acid from the laboratory before each sample run.

CAUTION: Chemicals used to preserve samples are extremely corrosive and should be handled carefully. If you spill these chemicals on your clothes, skin, or eyes, flush immediately and repeatedly with pH 6.9

Phosphate buffer. This is especially critical for an eye exposure. After rinsing with pH 6.9 buffer, continue to rinse with fresh water. For eye injuries get medical attention as soon as possible.

Place preserved and unpreserved samples in iced coolers and keep them cold until arrival at the laboratory.

Shipping/Lab Requests

Most samples should be returned to the laboratory at the end of each sampling day either by direct transport or shipping by commercial carrier. Some ground water samples may be shipped at less frequent intervals, depending on the analysis requested. Check with the laboratory manager before sampling for allowable holding times. Samples are most frequently shipped by Greyhound Bus Lines Package Express or U.S. Mail. Samples should be shipped in unbreakable iced coolers secured against leakage and tampering.

Samples submitted to the laboratory must be accompanied by a Laboratory Analysis Request Form (Figure 11). This form can be filled out by sampling personnel and shipped in the coolers or by the project manager and submitted directly to the laboratory. To complete the Request Form, list the sample number in the Sample ID column and circle each parameter you want analyzed. Designate whether you want total (T) or dissolved (D) nutrient forms analyzed. Fill in the name of the person who collected the samples, the project number and any comments you have. Describe the Sample Type as either freshwater, brackish, salt water,

ground water, precipitation or sediment. The laboratory will complete the data received section, the file number and record the date of analysis.

LABORATORY ANALYSIS REQUEST FORM

File # _____
 Date Rec'd _____
 Time Rec'd _____
 Sample Type _____

Project Mgr. _____
 Project # _____
 Collected by _____
 Date/Time Collected _____

LAB ID	# OF CONT	SAMPLE I.D.

LAB ID	# OF CONT	SAMPLE I.D.

PARAMETERS TO BE ANALYZED

PO4 _____	Color _____	SiO2 _____	Ca _____	As _____
NOX _____	Turb _____	F _____	Mg _____	Cd _____
NO2 _____	Alk _____	pH _____	Na _____	Ni _____
NH4 _____	Hard _____	Temp _____	K _____	Zn _____
NH4-D _____	SO4 _____	Cond _____	Fe _____	Ba _____
TP _____	Cl _____	TOC _____	Sr _____	Cr _____
TP-D _____	BOD _____	POH _____	Ag _____	Hg _____
TKN _____	TDS _____	Chl _____	Cu _____	Mn _____
TKN-D _____	TSS _____	_____	Se _____	Pb _____

Nutrients Preserved w/H₂SO₄ _____ Metals Preserved w/HNO₃ _____

Dissolved Nutrients Filtered _____ Dissolved Metals Filtered _____

Comments: _____

LABOR 11

QUALITY CONTROL

Quality Control is assured in the sampling program through various mechanisms. Instruments are calibrated before, during, and after use. Replicate samples are collected to evaluate sampling procedures. Blanks are preserved with acids used in the field to test their purity, and so forth.

One of the best methods of quality control is a trained sampler who does his job carefully. Take the time to collect samples and make measurements correctly.

In order to prevent deterioration of the samples and to obtain the most representative data, the Environmental Protection Agency has established guidelines for time frames in which an analysis must be completed (Table 3). For some parameters such as temperature and pH, the analysis should be completed on site, hence the portable instruments we use. Other analyses may be performed from water samples collected on site provided they satisfy suggested time frames. Since numerous parameters have 24-48 hour time frames for analysis, the samples should be returned to the laboratory overnight if possible. The project manager will notify you if less stringent time frames are to be met.

Field Calibration Check Sheet

This form is used to record calibration information for instruments used (Figure 12). Fill out the Name, Project Number, and Date Sections. Record the parameter measured, the instrument

TABLE 3

RECOMMENDED SAMPLE PRESERVATION
AND HOLDING TIME

<u>Measurement</u>	<u>Preservative</u> (1) (2)	<u>Holding Time</u>
<u>PHYSICAL PROPERTIES</u>		
Color	Cool, 4° C	48 Hrs.
Conductance	Cool, 4° C	28 Days
pH	None Req.	Analyze Immediately
Residue		
Filterable (TDS)	Cool, 4° C	7 Days
Non-Filterable (TSS)	Cool, 4° C	7 Days
Turbidity	Cool, 4° C	48 Hrs.
<u>METALS</u>		
Dissolved	Filter on site HNO ₃ to pH < 2 Cool, 4° C	6 Mos.
Total	HNO ₃ to pH < 2 Cool, 4° C	6 Mos.
Mercury, Total	HNO ₃ to pH 2 Cool, 4° C	28 Days
<u>INORGANICS</u>		
Alkalinity	Cool, 4° C	14 Days
Chloride	Cool, 4° C	28 Days
Fluoride	Cool, 4° C	28 Days
Silica	Cool, 4° C	28 Days
Sulfate	Cool, 4° C	28 Days
Hardness	Cool, 4° C	28 Days
<u>NUTRIENTS</u> (2)		
Ammonia Nitrogen	Cool, 4° C E ₂ SO ₄ to pH 2	28 Days
Total Kjeldahl Nitrogen	Cool, 4° C E ₂ SO ₄ to pH < 2	28 Days
Nitrate plus Nitrite	Cool, 4° C	48 Hrs.
	Cool, 4° C E ₂ SO ₄ to pH 2	28 Days
Orthophosphate	Cool, 4° C	48 Hrs.
	Cool, 4° C E ₂ SO ₄ to pH < 2	28 Days
Total Phosphorus	Cool, 4° C E ₂ SO ₄ to pH < 2	28 Days
<u>ORGANICS</u>		
BOD	Cool, 4° C	48 Hrs.
Total Organic Carbon (TOC)	Cool, 4° C E ₂ SO ₄ to pH < 2	28 Days
Purgeable Organic Halides and Purgeable Aromatics (EPA 601/602)	Cool to 4° C (add 10g sodium thiosulfate per 40 ml if sample contains chlorine)	14 Days
Chlorophyll	Cool, 4° C	48 Hrs.

1. HNO₃ to pH < 2 usually requires 0.5 ml of HNO₃ per 125 ml sample

FIELD CALIBRATION CHECK SHEET

FIGURE 12

NAME _____
 PROJECT NUMBER _____
 DATE _____

Parameter	Instrument ID	Calibration Time			Significant Error Amount/Time	Calibration Notes		
		Initial	Inter.	Final		Actual value (correct value) @		
					Initial	Interim	Final	

COMMENTS _____

ID (manufacturer and tag number), the time of initial, intermediary and final calibrations, and any significant errors. Record the correct value in parenthesis for D.O., pH, conductivity, and temperature. Record the temperature of buffers, standard solutions, or ambient air during air calibration. Note any problems with equipment in the comment section.

Field Replicate Samples

One replicate, or duplicate sample, is collected for every 20 regular samples. A replicate sample determines the repeatability of the sampling procedure and measurements. Two sets of measurements are taken and recorded on the Field Sheet. Fill out the appropriate Field Data measurements for one set of readings taken as usual, then repeat the measurements. The sample numbers will be the same, with FR added to the second number. To collect replicate samples, label duplicate sample bottles with the same sample number, adding an FR to the second sample number. Collect duplicate samples for each color coded label.

Standards

Standards will periodically be analyzed to verify the accuracy of analyses or measurements made in the field. The laboratory will supply standards to projects which regularly perform field analyses or following submittal of a Field Equipment and Supply Request Form. The same procedures followed in the field to measure (conductivity and pH) or analyze (alkalinity and chloride) samples should be followed to measure or analyze

standards. Report results on the Field Sheet and submit a copy to the laboratory.

Field Titration

Replicate, or duplicate, analyses should be performed for 10% of the samples analyzed for chloride or alkalinity by titration in the field. Titrate one sample out of every ten twice, report the results on the Field Sheet, and submit a copy to the laboratory.

Acid Preserved Blank

To determine whether preservative chemicals are adding impurities to the sample, a preserved blank is analyzed by the laboratory. Submit the preservatives used during each sample period to the laboratory with the samples. Record the dates used on the bottle label. Carefully seal the bottle to prevent leakage.

SITE EVALUATION

For most water quality monitoring projects the project manager will be responsible for evaluating and establishing sample stations. However, field personnel may be required to occasionally establish station locations.

Surface Water

In order to evaluate a potential station location, keep in mind you wish to collect a small sample which is representative of the larger area. In unfamiliar areas, consider whether you have a flowing stream or lake type situation. Make preliminary readings of conductivity, temperature and pH on a transect across the sampling area to determine mixing patterns. Consider the bathymetry of a sampling area, such as deep holes. If the system is stratified, poorly mixed or pocketed, consider collecting point samples and compositing them or choosing a more suitable location.

In stream sampling, try to sample in the flowing part rather than backwaters. Do not sample too close to bridge piers, directly below confluences, or directly below outfalls. Locate water quality stations near gaging stations when possible.

In establishing a sample station, keep accurate records of location, landmarks, and conditions. Remember, this site should be accessible year round unless it is a special site such as a marsh site. The three letter station code must be unique. Check

the master list before assigning a permanent station code to prevent duplication.

Ground Water

Ground water levels or water quality is obtained from wells, springs, seeps, lakes and streams. Seeps, lakes, and streams are manifestations of an unconfined or non-artesian surficial aquifer. Springs are manifestations of an artesian aquifer. Wells may be completed in a non-artesian aquifer, artesian aquifer or may be completed so they cross connect several aquifers. Water levels obtained from the surface water manifestations of ground water, springs, seeps, lakes, and streams can accurately depict water table conditions. However, water quality data collected from these sources may or may not be representative of the water quality in the aquifer due to mixing or geochemical reactions with the soil horizon if the waters flow through one. In addition, the aquifer or the zones within the aquifer supplying source water to a spring, may or may not be known. For the most part, it is better to rely first on observation wells than on springs, seeps, lakes, and streams, respectively, in attempting to collect representative ground water sampling.

When using a well for ground water monitoring, it is recommended that the following information be collected.

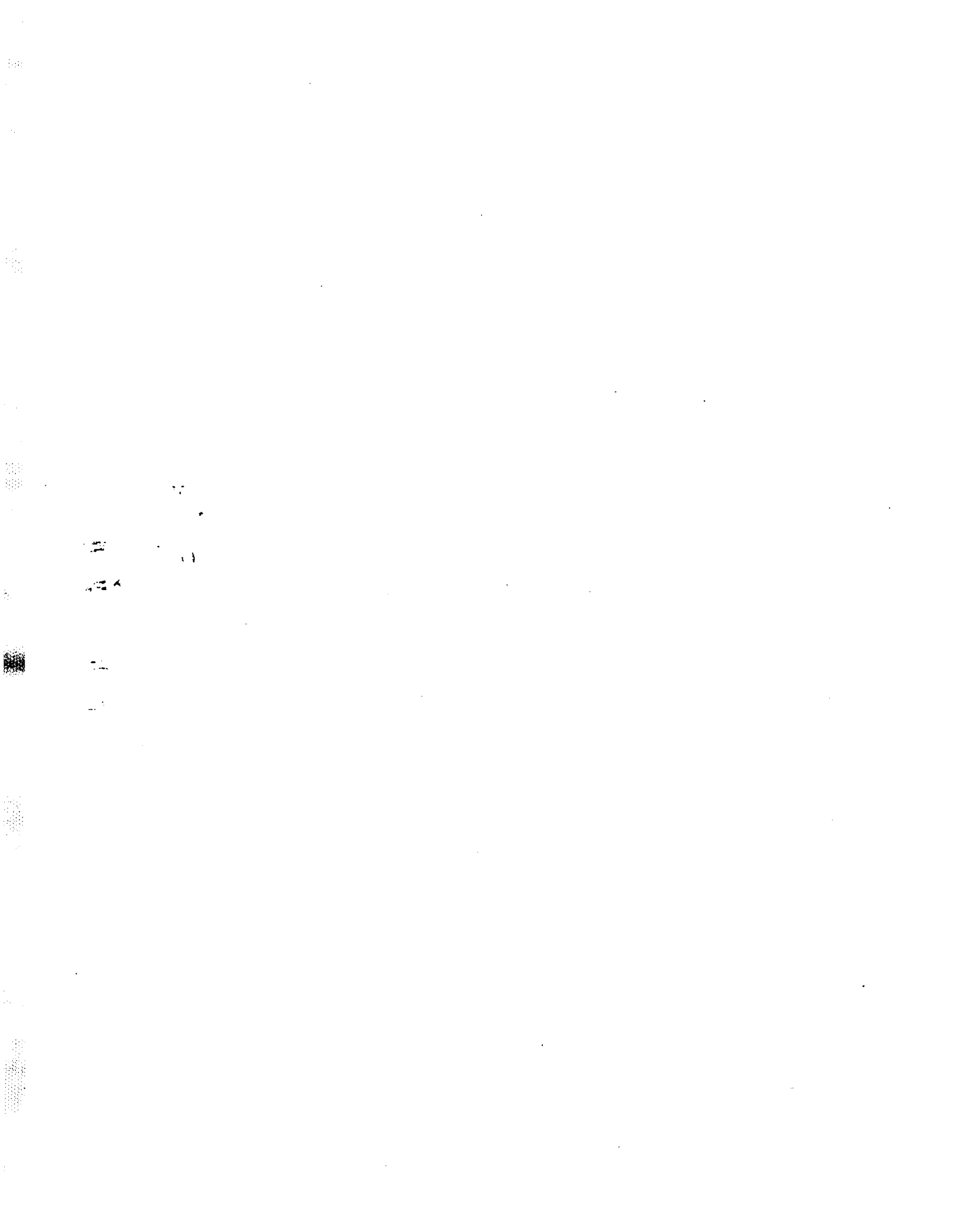
- Aquifer(s) tapped
- Aquifer hydrologic characteristics
- Lithologic and geophysical logs

- Well depth, size, type of casing or finish, location, and type of perforations
- Elevation of land surface and measuring point
- Diagram and photograph of well, showing access and measuring point
- Date drilled
- Well response data for unpumped wells (specific capacity test)
- Local well name and name, address and phone number of the owner
- Section, Township, Range, 1/4, 1/4, 1/4, and latitude and longitude
- Significant features near the well which could affect the water level (other wells, springs, seeps, etc.)
- Use of the well

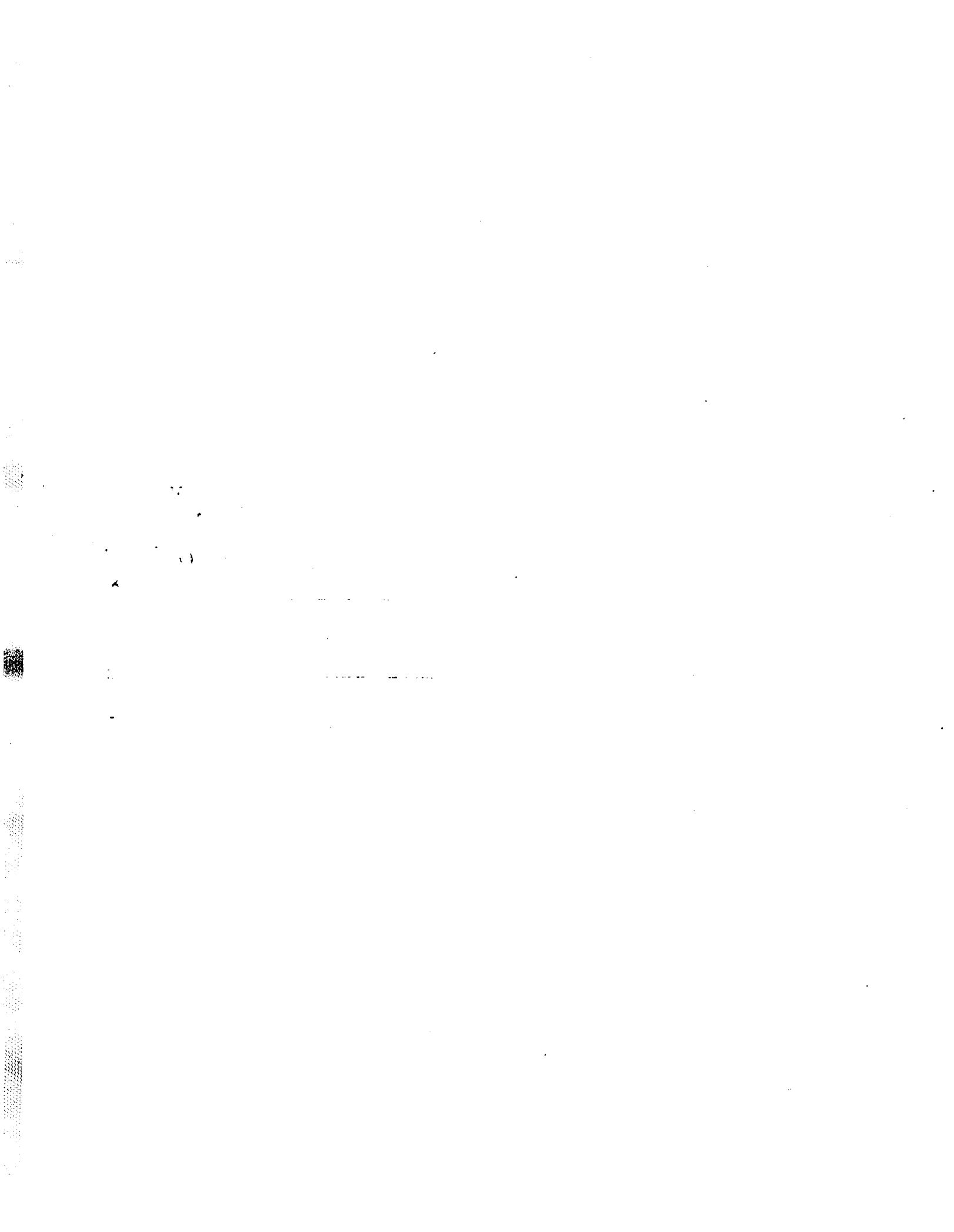
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APPENDIX A
Operation and Maintenance Instructions
Hydrolab Digital 4041



DIGITAL 4041 USER'S GUIDE

HOW THE 4041 WORKS

When the 4041 is in operation, the four parameters are being measured simultaneously at the sonde unit (underwater unit). The resulting signals are transmitted in parallel up the cable to the indicator unit. In the indicator unit, the signals may be amplified or shifted. After this processing, the signals are ready to be selected by the user (via the panel switch) for digital conversion and immediate read-out.

Calibration control(s) for each parameter are provided on the front panel of the indicator unit for user access. These controls are used to adjust the instrument before going to the field. This pre-field calibration adjusts for changes due to new pH fluid, a fresh D.O. membrane, re-polished conductivity electrodes, etc.

Zero-adjust controls are not provided because the 4041 circuits automatically null any zero-offsets that may appear in the system.

SOME DETAILS

Twelve wires connect the sonde unit to the indicator unit: (4) for Conductivity, (1) each for pH, D.O., and Common; (3) for Temperature; and (2) for Power.

Temperature is measured by a high accuracy thermistor, whose resistance goes down as its temperature increases. The thermistor is in the slim stainless steel tube in the bottom of the sonde unit. This single temperature signal is used to generate the automatic temperature compensation for the other three parameters.

Dissolved Oxygen is measured by the popular Clark polarographic cell. It is the plastic device with a gold ring in its end and a dull silver pellet in its center cavity. As oxygen diffuses through the Teflon membrane (according to its partial pressure), it is reduced by a polarizing voltage established between the gold and silver electrodes. This produces a measurable current proportional to the partial pressure. A constant polarizing voltage is maintained by the small 2.7 volt mercury battery located in the sonde unit. This battery should be changed approximately every three months. See the maintenance section for directions.

The pH of the sample is measured using a pH-sensitive glass electrode, which due to the sample pH, reaches a certain potential with respect to a reference electrode. This potential is amplified and buffered by the circuits in the sonde unit, and the resulting signal is sent to the indicator unit. The pH electrode is the glass tube with the small bulb on the end. The reference electrode is covered by a larger white plastic cover.

Conductivity is measured using the four-electrode technique. A large enough current is forced between two electrodes, through the resistive sample, to create a certain potential between two

other electrodes. The current required to maintain this potential is proportional to the conductivity, and this current is measured for display. The conductivity probe is easily recognizable by its gray epoxy body with four electrodes protruding from it into a white plastic cell.

The display is read in the following manner: temperature, pH, and dissolved oxygen are read out directly. For example, a temperature of 21.8°C will be displayed as 21.8. A D.O. or pH reading of 8.1 will be displayed as 08.1. Conductivity is read out directly on the 2K scale. If the 20K scale is being used, the number that is displayed will need to be multiplied by 10. In the 200K scale, the reading will be multiplied by 100. For example, suppose the sample being measured has a conductivity of 1527 uS/cm. Using the 2K scale, the display will show 1527 (direct read-out). Using the 20K scale, the display will show 153 (153 x 10 = 1530 uS/cm.). Using the 200K scale, the display will show 015 (015 x 100 = 1500 uS/cm.).

INITIAL PREPARATION

Your system has undergone a thorough calibration and testing procedure immediately prior to shipment. There are a few precautions that should be taken, however, before you attempt to connect the system components for operation:

Battery Charge: The battery should be fully charged when you receive it. It is advisable, however, to charge the battery for a period of 24 hours to avoid an unexpected loss of power during operation.

Underwater Connectors: In order to prevent unnecessary abrasion of the sealing surfaces of any underwater connector pair, a very light coating of the underwater connector lubricant should be applied to both sealing surfaces before you attempt to mate them.

CONNECTING THE SYSTEM COMPONENTS

Sonde Unit to Underwater Cable: This paragraph applies only to those units that were ordered with Marine Connectors. Connect the sonde unit to the underwater cable by carefully aligning and mating the two halves of the 12-pin connector pair. This operation often requires considerable force, and care should be taken to expel any air that may be trapped within the connector cavity.

Circulator Motor to Sonde Unit: This paragraph applies only to those units that were ordered with a Circulator. Connect the (2-pin) connector that breaks out from the top cap connector to the 2-pin motor lead by aligning the large pin on the male half with the raised nub on the female half. Expel any air that may be trapped within the connector cavity.

Battery Pack to Indicator Unit: Attach the battery cable to the indicator unit connector marked "12 VOLTS DC INPUT".

CALIBRATION

The procedures for calibrating the 4041 are simple and easy to perform. However, in order to expect good results in the field, all calibration checks which are pertinent to the measuring systems must be performed. Take no shortcuts. This is

important since calibration errors will be reflected in the accuracy of all subsequent measurements.

Frequency of Calibration: A complete calibration check should be accomplished before going to, and after returning from the field. This dual calibration procedure will afford judgment as to drift due to sensor fouling and to the frequency and type of sensor maintenance required between field operations. Because of a multitude of variables encountered under differing field conditions, there is no rule-of-thumb in establishing: 1) the length of time that a system may be deployed without recalibration or 2) the extent of cleaning and maintenance required between field operations. These judgments are made on a case-by-case basis and should be expected to change in time.

Conditions: The calibration procedures should be carried out in a place where ambient conditions are under control and where there is a readily available supply of distilled or deionized water, reliable calibration standard solutions and maintenance items. Generally, the laboratory is best suited but a field office or closed-in shelter will suffice.

Required Materials: In order to properly calibrate the 4041, the following items will be needed:

- (1) Calibration cup
- (2) Two reliable KCl standard solutions (known conductivity)
- (3) Two freshly prepared pH buffer solutions. Generally pH 7.0 and either pH 4.0 or 9.18 are used depending upon the measuring assignment.

- (4) Distilled water or de-ionized water (approximately two liters)
- (5) Absorbent tissue
- (6) Two screwdrivers (supplied in Accessory Kit)

Calibration Procedure: At least one hour prior to calibrating the system (preferably the night before), take the following preparatory steps.

- (1) Remove the "Storage-Cup" from the sonde unit.
- (2) Remove the protective guard from the dissolved oxygen sensor.
- (3) Install the "Calibration-Cup" on the sonde unit and fill to the brim with tap water.
- (4) Seal the Calibration Cup with the soft plastic cap and store the sonde unit, calibration standards, and the distilled water at constant room temperature for at least one hour in order to bring the various sensors, temperature compensating elements, and the calibration solutions into thermal equilibrium (within a few degrees).

All of the calibration controls are located on the front panel of the indicator unit. Adjustments, if necessary, should be made in the following manner:

- (1) Remove the appropriate seal-screw for the parameter being adjusted.
- (2) Insert the small screwdriver through the access hole and adjust the calibration control in the direction which

brings the reading into agreement with the value of the standard solution being employed.

(3) Replace the seal-screw.

A Rinse Step will be used several times during the calibration procedure. It is to be performed in the following manner: Fill the calibration cup halfway with de-ionized water (or distilled). Snap on the soft plastic cap; shake the sonde unit for ten seconds and then pour out the water. Repeat twice more using fresh de-ionized water. Remove the cup and shake as much of the rinse water as possible from the electrodes.

Dissolved Oxygen Calibration: The Dissolved Oxygen system is the first to be calibrated since the water that has been stored in the calibration cup is used to maintain control of the temperature inside the cup. The calibration standard is "water-saturated air at the temperature of the D.O. cell."

Invert the sonde unit and remove the soft plastic cap. Pour off enough water to bring the level to just below the D.O. membrane-retaining O-ring. With a clean paper towel or tissue, blot any moisture from the D.O. membrane. Cover the calibration cup mouth with one of the hard plastic caps provided in the Accessory Kit. This will keep drafts from blowing on the membrane. Do not seal the cup with the soft plastic cap because that could cause a partial-pressure change in the cup. Wait approximately five minutes, or until the reading is stable, then switch to the TEMPERATURE position and record the temperature reading. Refer to the solubility table for the correct oxygen concentration at this temperature. Since the table values refer

to concentrations at Standard Pressure, it will be necessary to correct the value for local barometric pressure. This should be done in the following manner:

Correct D.O. Setting = (Pressure/760mm) x (Table value at Cup
Temperature)

EXAMPLE: If T = 28.7°C and Pressure = 80mm,

Correct D.O. Setting = (800mm/760mm) x 7.67mg/l = 8.07mg/l

If you don't have a barometer, the equivalent pressure may be estimated from your altitude by recalling that atmospheric pressure drops from standard sea-level pressure (760mm Hg) at the approximate rate of 2.5mm for every 100 feet of elevation.

Therefore, the approximate atmospheric pressure at an altitude of 1240 feet, for example, would be:

Local Atmospheric Pressure - 760mm - (2.5 x 12.4) = 729mm Hg.

Adjust the Dissolved Oxygen calibration control until the proper value (rounded to nearest tenth) is displayed. Pour out the water; and then follow with the RINSE STEP.

pH Calibration: Calibrating the pH system requires the use of two pH buffer solutions. Depending upon the application, either pH 4.0 or pH 9.18 is used in addition to pH 7.0. Invert the sonde unit and fill the calibration cup with fresh pH 7.0 buffer solution. Switch to "pH," and wait approximately five minutes for thermal equilibrium. Then adjust the pH calibration control until 7.0 is displayed on the read-out.

Pour out the 7.0 buffer and repeat the RINSE STEP. Invert the sonde unit and screw on the calibration cup; fill with 9.18 or 4.0 buffer. After approximately five minutes, adjust the pH

"Slope" control until either 9.2 or 4.0 is displayed on the read-out. Pour out the buffer and repeat the RINSE STEP two times.

Conductivity Calibration: After the second RINSE STEP, take a clean paper towel or tissue and blot most of the moisture in the electrode area so that the standard will not suffer dilution.

Install a clean calibration cup and invert the sonde unit. The conductivity system is calibrated using at least two prepared KCl standard solutions with a known conductivity at 25°C. From the table, select two standard solutions with values of approximately one third and two thirds of the range you are most likely to encounter in the field. For example, if you are going to be working in fresh water (0-2K scale), you would want to use a 0.01M standard and a 0.005M standard. Select the more concentrated of the two standards and pour it slowly down the side of the calibration cup until full. If there are any bubbles in the bores of the conductivity cell block, fill the calibration cup again. When the reading is stable, adjust the conductivity calibration control until the display matches the value listed in the table. Empty the calibration cup and repeat the RINSE STEP two times. Pour in the second standard. Check the reading on the display. It should be correct within $\pm 1\%$ of the range being used. For example, if the 0-2K scale is used, the reading for the second standard should be correct $\pm 20\mu\text{S}/\text{cm}$. Pour out the standard solution.

Temperature Calibration: The Temperature system is factory calibrated and is accurate to $\pm 0.2^\circ\text{C}$. No calibration adjustment is provided. A periodic check of the temperature system against

a customer-owned ASTM thermometer could be helpful in detecting a system malfunction. Twenty minutes in a large, vigorously-stirred bath is necessary.

FINAL PREPARATION

Turn the system off and disconnect the system components. Replace all rubber dust caps. Remove the Calibration Cup from the sonde unit and replace the protective guard on the dissolved oxygen electrode. Install the Storage Cup, filled with tap water, onto the sonde unit. The system is now calibrated and ready for transport to the field.

FIELD OPERATION

Remove the Storage Cup from the calibrated sonde unit and install the guard or the optional sample circulator. Connect the system components. Lower the sonde unit into the water (sideways, if possible) and shake it to dislodge air bubbles trapped in the conductivity cell block. Release the sonde unit and lower it to sample depth. Wait until the readings stabilize (D.O. is the best indicator), then record the value for each parameter. Repeat at new depths or locations.

Figure 1 provides the user with a way to determine sea water salinity from the conductivity readings obtained via the 4041. Figure 2 allows the user to correct Dissolved Oxygen readings for the "salting-out" effect of ionic solutions. The Dissolved Oxygen correction factor is temperature-dependent, so use the appropriate curve. The 25°C curve should always be used in Figure 1, however.

Check the battery voltage occasionally; charge or change batteries if the level drops below 10.5 volts. DO NOT charge the battery routinely after each day's use. Doing so may shorten the life of the battery. Use the battery until the voltage level drops to between 10.5 and 11.0 volts. At this point put the battery on charge for 14 hours.

The instrument case is hermetically sealed against moisture and dust. As long as the case seals are intact, the 4041 may be operated without harm in heavy rain or spray. The liquid crystal display is protected during cold weather by a built-in heater circuit which is automatically energized when temperatures drop below freezing. As long as the external battery is connected to the instrument, the liquid crystal display is protected against freezing, down to a temperature of -20°C .

STANDARD MAINTENANCE

As long as the 4041 is functioning properly, there is no need to perform the following maintenance procedures. However, in the event of biological or chemical fouling, these steps are necessary to restore the measuring elements to like-new condition.

Servicing the Probes:

- (1) Remove the conductivity cell block by unscrewing the two screws that hold it to the gray epoxy electrode mount. Carefully remove the O-rings from the electrodes. Polish the electrodes with a strip of fine emery cloth, being careful not to scratch the nearby pH bulb. Polish the entire surface of each electrode, including the

ends. Now, rinse any sanding residue away from the conductivity electrodes, and push the O-rings onto the electrodes. Carefully re-install the cell block and tighten it until the O-rings are about 2/3 as thick as they were when not compressed.

- (2) Remove the reference electrode sleeve by pointing it toward the floor (it's full of buffer solution) and twisting it while pulling downward (it's held on by a single O-ring). Discard the old buffer. Fill the reference electrode sleeve to the brim with fresh pH 7.00 buffer solution. Without tilting it, push it back on until it seals on the O-ring. Invert the assembly (sleeve pointing up now). Push and twist the sleeve down until it butts against the bottom cap. The 7.00 buffer solution should have bubbled through the porous tip of the sleeve; if not, repeat the procedure. For illustration, please refer to Figure 4.
- (3) Remove the Dissolved Oxygen cell guard. Remove the D.O. cell membrane-retaining O-ring. Discard the old membrane and shake out the old electrolyte solution. With the gold electrode facing up, hold a membrane against the side of the D.O. cell with a thumb. Using the other hand, fill the cell cavity with fresh D.O. electrolyte. If a bubble is visible in the cell beneath the silver pellet electrode, shake out the cell and refill the cavity slowly. Overfill the cavity, creating a high meniscus, then still holding the membrane with a

thumb, grasp the free end of the membrane and pull it quickly and tightly over the meniscus. Please refer to Figure 3.

A quick firm pull is necessary to prevent wrinkling and additional bubble entrapment. If bubbles are visible beneath the membrane, or if tiny wrinkles are visible just outside the gold ring, start over with a new membrane. Otherwise, secure the membrane by rolling the membrane O-ring over the membrane, into its groove.

Check the membrane again for wrinkles, then trim the excess membrane. Replace the D.O. guard.

- (4) Screw on the calibration cup and fill it about half full of water. Add some detergent. Install the soft plastic cap and shake the sonde unit for 20-30 seconds. Pour out the soapy water. Fill the calibration cup half full of clean water; install the soft plastic cap and shake it for 10 seconds. Pour out the water and repeat twice using clean water each time. Remove the calibration cup. Fill the storage cup three-quarters full of clean water and screw it onto the sonde unit.

NOTE: If the sonde unit is to be stored for several days or more, add some Alconox or similar detergent to the water in the storage cup. This will help retard biological growth.

SERVICING THE D.O. POLARIZING BATTERY

- (1) Remove the two allen-head screws from the top of the sonde tube.
- (2) Pull off the top cap by grasping the exposed plastic portion. (It might be helpful to insert the tip of a small screwdriver between the tube and top cap to start the process.) DO NOT pull on the connector.
- (3) Remove the battery retaining clip and install the new battery. Replace the retaining clip.
- (4) Make sure the sealing O-rings on the top cap are clean. Clean off any residue that may be present inside the tube.
- (5) Take a small amount of the white O-ring grease and smear a light coating on the O-rings and on the sealing surface of the tube.
- (6) Install the top cap and screws.
- (7) Hold the sonde unit up to the light in a horizontal position, and check to see that all of the O-rings have made a good seal. If not repeat steps 1, 2, 6, and 7.

COMMON PROBLEMS AND SOLUTIONS

<u>SYMPTON</u>	<u>CAUSE</u>	<u>SOLUTION</u>
(1) D.O. Reads Low	Low Battery in Sonde Unit. . . . .	.Confirm battery voltage is 2.7v
	Insufficient Stirring. . . . .	.Check to see that Circulator is working properly i.e. No shorts in the motor lead
	Contaminated Cell or Membrane. . . . .	.Replace the membrane
(2) D.O. Reads "00.0"	Mercury Battery in Sonde Loose . . . . .	.Open sonde and check connection and voltage on mercury battery replace battery or secure connection
	No Power to Sonde Board. . . . .	.For power problems, consult factor
(3) D.O. Too High to Calibrate	Wrong Membrane (Too Thin), . . . . .	.Replace membrane making sure the membrane is from a packet marked "standard"
	Membrane Stretched Too Tight, Hole in Membrane, Wrinkle in Membrane	
4) D.O. Reads abnormally high or low (EX: 55.0mg/l)	Dead Battery in Sonde Unit . . . . .	.Replace mercury battery
	No Power to Sonde Board. . . . .	.For power problems, consult factor
5) D.O. Reading Drifts or is unstable during Calibration	Contaminated Membrane. . . . .	.Replace Membrane
	Air Bubble on Outside of Membrane. . . . .	."Jig the sonde unit up and down in the water to dislodge any trapped bubbles
6) D.O. Reading Drifts or is unstable In-Situ	Contaminated Membrane. . . . .	.Replace Membrane
	Erratic Circulation. . . . .	.Check circulator operation, or if no circulator, maintain circulation of at least 1 FPM.

<u>SYMPTOM</u>	<u>CAUSE</u>	<u>SOLUTION</u>
pH Slope Will Not Adjust to 9.2 or 4.0	Bad Buffer Clogged Reference Junction or Buffer Solution inside Reference is bad Cracked or Scratched pH Bulb . . . . .	.Mix up new Buffer and repeat .Refill reference probe with fresh pH 7.0 Buffer .Check pH Probe for scratches, cracks, or internal bubbles. If pH Probe is bad consult factory for replacement.
pH Response very slow	Clogged Reference Junction, Cracked or Scratched pH Bulb	.Please refer to #1 above.
pH Won't Respond	Cracked Bulb; No Power to Sonde Board Reference Filling Solution Low . . . . .	.Consult factory for replacement of broken Probe or power problems .Refill Reference Probe with fresh pH 7.0 Buffer.
pH Unstable	Bubble in pH Bulb; Cracked or Scratched pH Bulb Clogged Reference Junction Loose Reference Sleeve . . . . .	.Consult factory for pH Probe replacement .Refill Reference with fresh pH 7.0 Buffer .Make sure the Reference Sleeve is seated tightly over the O-Ring
pH Negative or Over 14	No power to Sonde Board; Electrode(s) Disconnected Electrode(s) Not in Solution . . . . .	.Consult factory for repair checks .Make sure Probes are in solution

<u>SYMPTOM</u>	<u>CAUSE</u>	<u>SOLUTION</u>
Conductivity Reads Low In-Situ or during Calibration	Bubble in Cell Bore or in Probe Area of Sonde Unit	"Jig" the Sonde Unit up and down in the water to dislodge any trapped bubbles
	Dirty Electrodes	Clean the Electrodes
	Bad Calibration	Recheck Calibration with fresh standards
Conductivity Unstable In-Situ or during Calibration	Bubble in Cell Bore; Bubble in Probe Area of Sonde Unit	Dislodge any Bubbles as described in #1 above
	Cell Block Loose	Check Cell Block to see that it is secure
	Dirty Electrodes	Clean the Electrodes and recalibrate
Conductivity Does Not Fall into Specs (+/-0.0% of Range) during Calibration	Bubble in Cell Bore	Check for Bubbles and dislodge any that are present
	Dirty Electrodes	Clean the Electrodes
	Bad Standard	Mix new standards and recalibrate

TEMP.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	14.16	14.12	14.08	14.04	14.00	13.97	13.93	13.89	13.85	13.81
1	13.77	13.74	13.70	13.66	13.63	13.59	13.55	13.51	13.48	13.44
2	13.40	13.37	13.33	13.30	13.26	13.22	13.19	13.15	13.12	13.08
3	13.05	13.01	12.98	12.94	12.91	12.87	12.84	12.81	12.77	12.74
4	12.70	12.67	12.64	12.60	12.57	12.54	12.51	12.47	12.44	12.41
5	12.37	12.34	12.31	12.28	12.25	12.22	12.18	12.15	12.12	12.09
6	12.06	12.03	12.00	11.97	11.94	11.91	11.88	11.85	11.82	11.79
7	11.76	11.73	11.70	11.67	11.64	11.61	11.58	11.55	11.52	11.50
8	11.47	11.44	11.41	11.38	11.36	11.33	11.30	11.27	11.25	11.22
9	11.19	11.16	11.14	11.11	11.08	11.06	11.03	11.00	10.98	10.95
10	10.92	10.90	10.87	10.85	10.82	10.80	10.77	10.75	10.72	10.70
11	10.67	10.65	10.62	10.60	10.57	10.55	10.53	10.50	10.48	10.45
12	10.43	10.40	10.38	10.36	10.34	10.31	10.29	10.27	10.24	10.22
13	10.20	10.17	10.15	10.13	10.11	10.09	10.06	10.04	10.02	10.00
14	9.98	9.95	9.93	9.91	9.89	9.87	9.85	9.83	9.81	9.78
15	9.76	9.74	9.72	9.70	9.68	9.66	9.64	9.62	9.60	9.58
16	9.56	9.54	9.52	9.50	9.48	9.46	9.45	9.43	9.41	9.39
17	9.37	9.35	9.33	9.31	9.30	9.28	9.26	9.24	9.22	9.20
18	9.18	9.17	9.15	9.13	9.12	9.10	9.08	9.06	9.04	9.03
19	9.01	8.99	8.98	8.96	8.94	8.93	8.91	8.89	8.88	8.86
20	8.84	8.83	8.81	8.79	8.78	8.76	8.75	8.73	8.71	8.70
21	8.68	8.67	8.65	8.64	8.62	8.61	8.59	8.58	8.56	8.55
22	8.53	8.52	8.50	8.49	8.47	8.46	8.44	8.43	8.41	8.40
23	8.38	8.37	8.36	8.34	8.33	8.32	8.30	8.29	8.27	8.26
24	8.25	8.23	8.22	8.21	8.19	8.18	8.17	8.15	8.14	8.13
25	8.11	8.10	8.09	8.07	8.06	8.05	8.04	8.02	8.01	8.00
26	7.99	7.97	7.96	7.95	7.94	7.92	7.91	7.90	7.89	7.88
27	7.86	7.85	7.84	7.83	7.82	7.81	7.79	7.78	7.77	7.76
28	7.75	7.74	7.72	7.71	7.70	7.69	7.68	7.67	7.66	7.65
29	7.64	7.62	7.61	7.60	7.59	7.58	7.57	7.56	7.55	7.54
30	7.53	7.52	7.51	7.50	7.48	7.47	7.46	7.45	7.44	7.43
31	7.42	7.41	7.40	7.39	7.38	7.37	7.36	7.35	7.34	7.33
32	7.32	7.31	7.30	7.29	7.28	7.27	7.26	7.25	7.24	7.23
33	7.22	7.21	7.20	7.20	7.19	7.18	7.17	7.16	7.15	7.14
34	7.13	7.12	7.11	7.10	7.09	7.08	7.07	7.06	7.05	7.05
35	7.04	7.03	7.02	7.01	7.00	6.99	6.98	6.97	6.96	6.95

TABLE OF OXYGEN SOLUBILITY IN % CHLORINITY, 760mm Hg

CHLORIDE SOLUTIONS AT 25°C
M.W. = 74.555

4041 DISPLAY FOR GIVEN
RANGE SETTING (uS/cm)

CONC. M		GRAMS/L KCl		uS/cm
0.0005		0.03728		73.9
0.001		0.07456		147.0
0.002		0.1491		292.0
0.005		0.3728		717.8
0.01		0.7456		1.413K
0.02		1.491		2.767K
0.05		3.728		6.668K
0.1		7.456		12.90K
0.2		14.911		24.82K
0.5		37.278		58.64K
1.0		74.555		111.9K

(0-2K)	(0-20K)	(0-200K)
147		
292		
718		
1413	141	
---	277	
---	667	
---	1290	129
---	---	248
---	---	586
---	---	1119

- NOTES: (1) Two conductivity standards are recommended for each range setting (boxed-in values).
Make calibration adjustments with the higher concentration and check with the lower concentration.
- (2) Shaded areas are not recommended for calibration checks.

ELECTRICAL CONDUCTIVITY OF SEAWATER

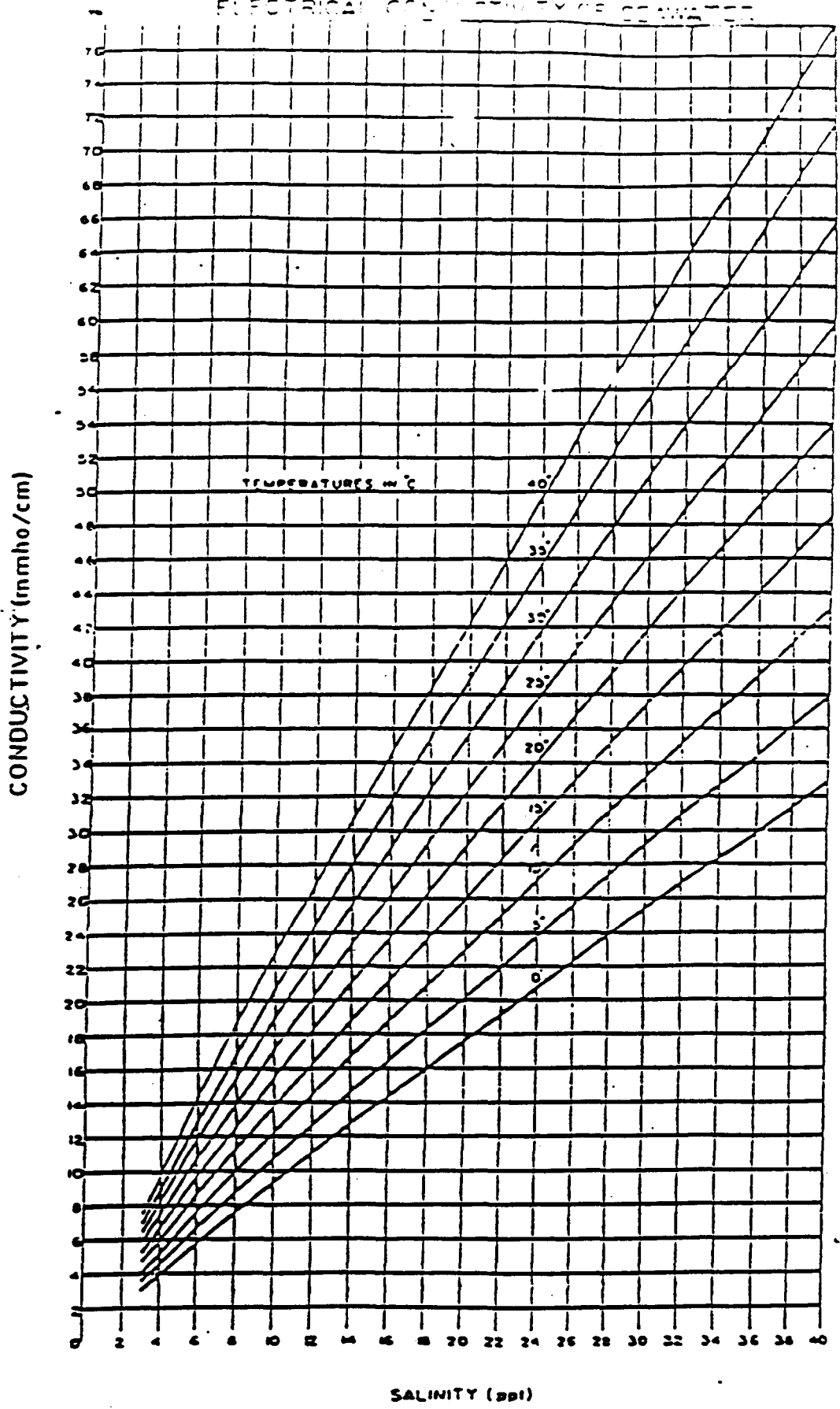


FIGURE 1 CONDUCTIVITY OF SEAWATER (mmho/cm) VS. SALINITY (ppt)

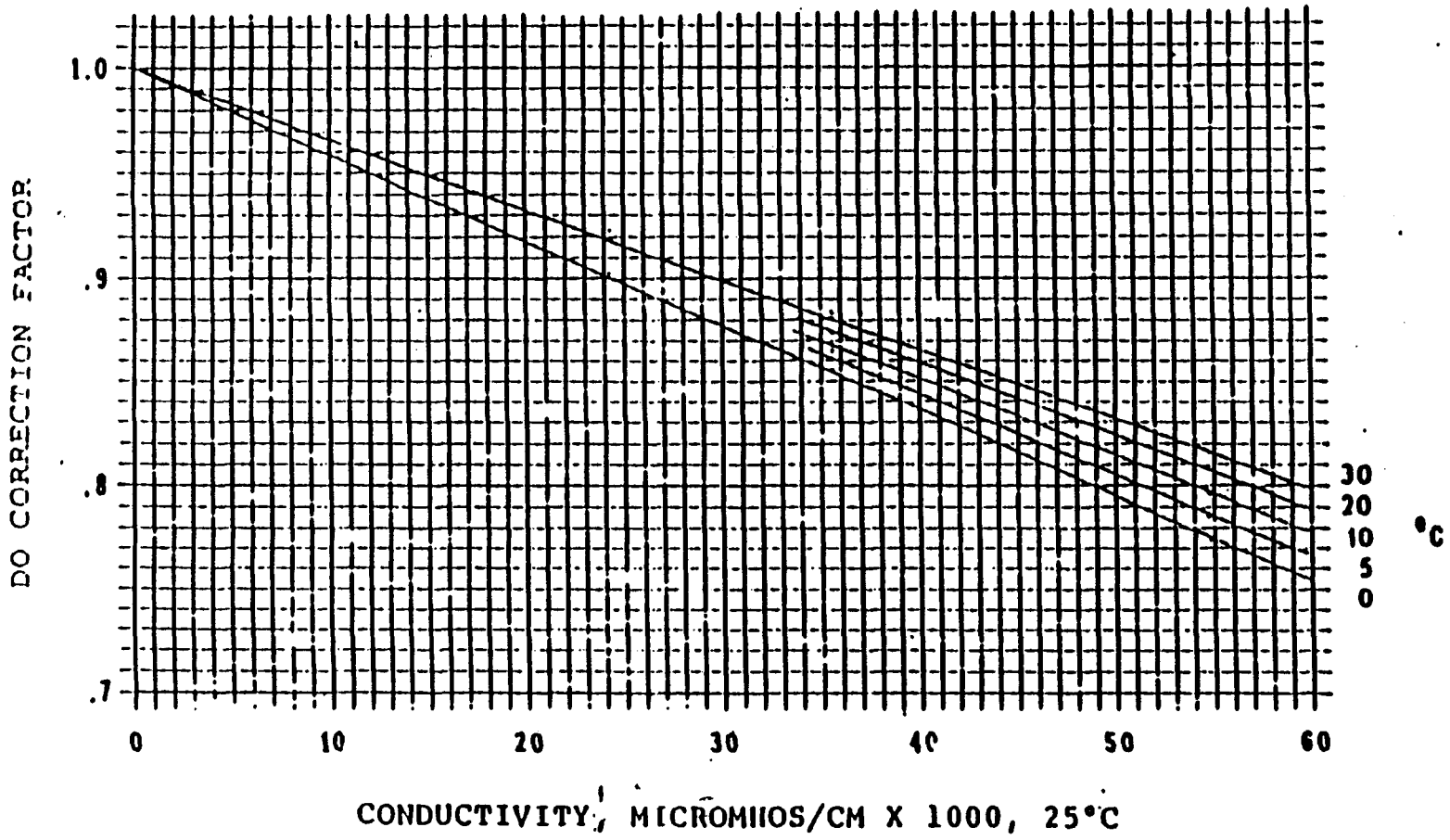


FIGURE 2 CORRECTING DISSOLVED OXYGEN MEASUREMENTS FOR VARIATIONS IN CONDUCTIVITY

APPENDIX B
Instruction Manual
YSI Model 57 Dissolved Oxygen Meter

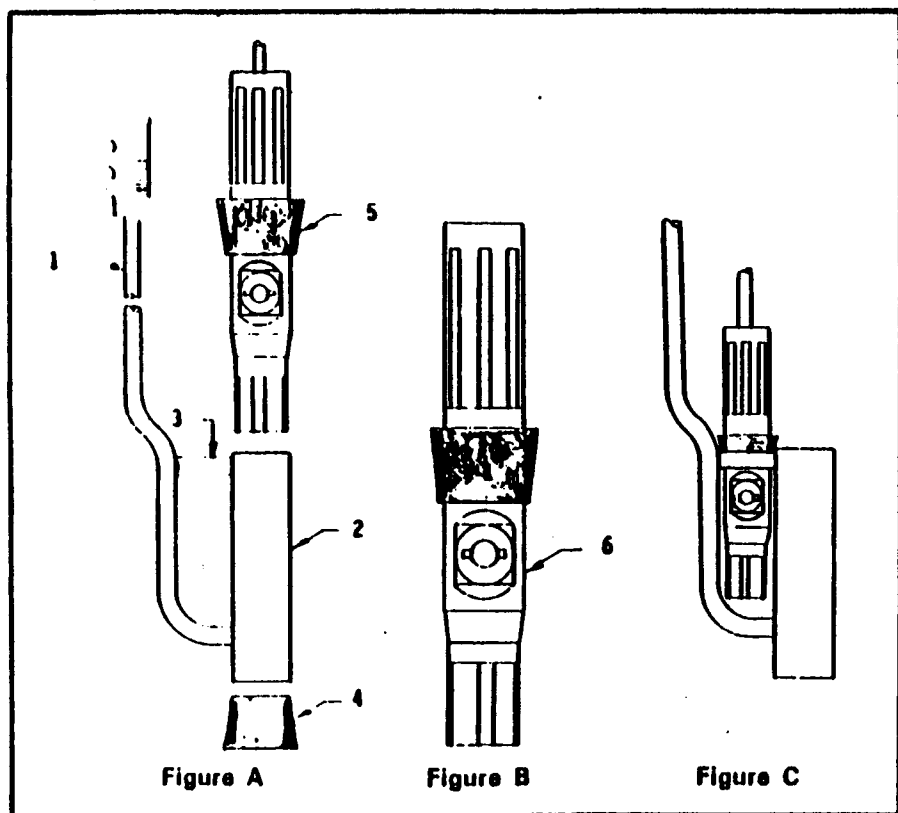
Calibration Chamber

The YSI 5075A Calibration Chamber is an accessory that helps obtain optimum calibration in the field and is also a useful tool for measuring at shallow depths (less than 4').

As shown in Figure (A), it consists of a 4-1/2 foot stainless steel tube (1) attached to the calibration chamber (2), the measuring ring (3), and two stoppers (4) and (5).

For calibration, insert the solid stopper (4) in the bottom of the calibration chamber (2). Push the oxygen probe (6) through the hollow stopper (5) as shown in Figure (B). Place the probe in the measuring ring, Figure (C), and immerse the probe in the sample to be measured for five minutes to thermally equilibrate the probe. Quickly transfer the probe to the calibration chamber (5) draining excess water from the chamber and shaking any excess droplets from the probe membrane. For maximum accuracy, wet the inside of the calibration chamber with fresh water. This creates a 100% relative humidity environment for calibration. Place the chamber in the sample for an additional five minutes for final thermal equilibrium. Calibrate the probe as described in the air-calibrator procedure. Keep the handle above water at all times.

After calibration, return the probe to the measurement ring for shallow measurements. Move the probe up and down, or horizontally, approximately one foot a second while measuring. In rapidly flowing streams (greater than 5'/second) install the probe in the measuring ring with the pressure compensating diaphragm towards the chamber.



IV. Dissolved Oxygen Measurement

With the instrument prepared for use and the probe calibrated, place the probe in the sample to be measured and provide stirring.

1. Stirring for the 5739 Probe can best be accomplished with a YSI submersible stirrer. Turn the STIRRER knob ON. If the submersible stirrer is not used, provide manual stirring by raising and lowering the probe about 1 ft. per second. If the 5075A Calibration Chamber is used, the entire chamber may be moved up and down in the water at about 1 ft. per second.
2. The YSI 5720A has a built-in power driven stirrer.
3. With the YSI 5750 sample stirring must be accomplished by other means such as with the use of a magnetic stirring bar.
4. Adjust the SALINITY knob to the salinity of the sample.
5. Allow sufficient time for probe to stabilize to sample temperature and dissolved oxygen. Read dissolved oxygen.

V. Calibration Tables

Table I shows the amount of oxygen in PPM that is dissolved in air saturated fresh water at sea level (760 mmHg atmospheric pressure) as temperature varies from 0° to 45°C.

Table I — Solubility of Oxygen in Fresh Water

Temperature °C	PPM Dissolved Oxygen	Temperature °C	PPM Dissolved Oxygen
0	14.6	23	8.7
1	14.2	24	8.6
2	13.9	25	8.4
3	13.5	26	8.2
4	13.2	27	8.1
5	12.8	28	7.9
6	12.6	29	7.8
7	12.2	30	7.7
8	11.9	31	7.5
9	11.6	32	7.4
10	11.3	33	7.3
11	11.1	34	7.2
12	10.8	35	7.1
13	10.6	36	7.0
14	10.4	37	6.8
15	10.2	38	6.7
16	9.9	39	6.6
17	9.7	40	6.5
18	9.5	41	6.4
19	9.3	42	6.3
20	9.2	43	6.2
21	9.0	44	6.1
22	8.8	45	6.0

It is important that the instrument be placed in the intended operating position vertical, tilted, or on its back — before it is prepared for use and calibrated. (See Figure 8) Readjustment may be necessary when the instrument operating position is changed. After preparing the probe proceed as follows:

1. With switch in the OFF position, adjust the meter pointer to Zero with the screw in the center of the meter panel. Readjustment may be necessary if the instrument position is changed.
2. Switch to RED LINE and adjust the RED LINE knob until the meter needle aligns with the red mark at the 31°C position.
3. Switch to ZERO and adjust to zero with zero control knob.
4. Attach the prepared probe to the PROBE connector of the instrument and adjust the retaining ring finger tight.
5. Before calibrating allow 15 minutes for optimum probe stabilization. Repolarize whenever the instrument has been OFF or the probe has been disconnected.

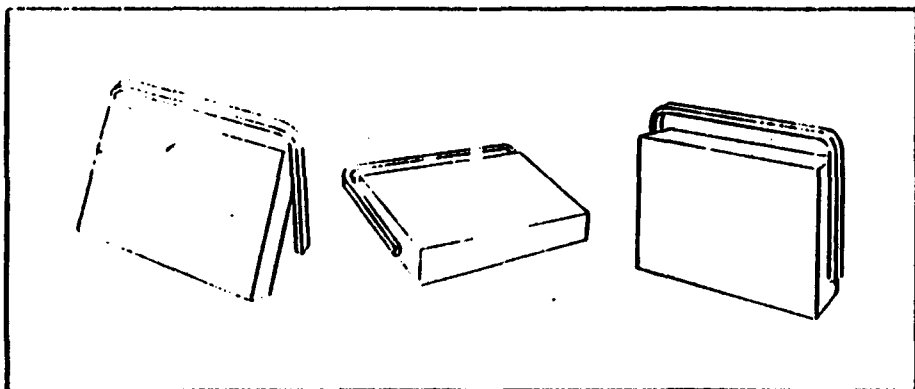


FIGURE 8

III Calibration

The operator has a choice of three calibration methods — Winkler Titration, Saturated Water, and Air. Experience has shown that air calibration is quite reliable yet far simpler than the other two methods. The three methods are described in the following paragraphs.

Winkler Titration

1. Draw a volume of water from a common source and carefully divide into four samples. Determine the oxygen in three samples using the Winkler Titration technique and average the three values. If one of the values differs from the other 2 by more than 0.5 ppm, discard that value and average the remaining two.
2. Place the probe in the fourth sample and stir.
 1. Set the SALINITY control to zero or the appropriate salinity value of the sample.
4. Switch to desired PPM range and adjust the CALIBRATION control to the average value determined in Step 1. Allow the probe to remain in the sample for at least two minutes before setting the calibration value, and leave in the sample for an additional 2 minutes to verify stability. Readjust if necessary.

1. Air saturate a volume of water (300-500cc) by aerating or stirring for at least 15 minutes at a relatively constant temperature.
2. Place the probe in the sample and stir. Switch to TEMPERATURE. Refer to Table I for the PPM value corresponding to the temperature.
3. Determine local altitude or the "true" atmospheric pressure (note that "true" atmospheric pressure is as read on a mercury barometer. Weather Bureau reporting of atmospheric pressure is corrected to sea level). Using Table II determine the correct factor for your pressure or altitude.
4. Multiply the PPM value from Table I by the correction factor from Table II to determine the corrected calibration value for your conditions.

EXAMPLE: Assume temperature = 21°C and altitude = 1000 feet. From Table I the calibration value for 21°C is 9.0 PPM. From Table II the correction factor for 1000 feet is about 0.96. The corrected calibration value is $9.0 \text{ PPM} \times 0.96 = 8.6 \text{ PPM}$
5. Switch to an appropriate PPM range, set the SALINITY knob to zero, and adjust the CALIBRATE knob while stirring until the meter reads the corrected calibration value from Step 4. Leave the probe in the sample for two minutes to verify calibration stability. Readjust if necessary.

Air Calibration

1. Place the probe in moist air. BOD probes can be placed in partially filled (50 mL) BOD bottles. Other probes can be placed in the YSI 5075A Calibration Chamber (refer to the following section describing calibration chamber) or the small storage bottle (the one with the hole in the bottom) along with a few drops of water. The probe can also be wrapped loosely in a damp cloth taking care the cloth does not touch the membrane. Wait approximately 10 minutes for temperature stabilization.
2. Switch to TEMPERATURE and read. Refer to Table I — Solubility of Oxygen in Fresh Water, and determine calibration value.
3. Determine altitude or atmospheric correction factor from Table II.
4. Multiply the calibration value from Table I by the correction factor from Table II.

EXAMPLE: Assume temperature = 21°C and altitude = 1000 feet. From Table I the calibration value for 21°C is 9.0 PPM. From Table II the correction factor for 1000 ft. is about 0.96. Therefore, the corrected calibration value is $9.0 \text{ PPM} \times 0.96 = 8.6 \text{ PPM}$.
5. Switch to the appropriate PPM range, set the SALINITY knob to zero and adjust the CALIBRATE knob until the meter reads the correct calibration value from Step 4. Wait two minutes to verify calibration stability. Readjust if necessary.

The probe is now calibrated and should hold this calibration value for many measurements. Calibration can be disturbed by physical shock, touching the membrane, or drying out of the electrolyte. Check calibration after each series of measurements and in time you will develop a realistic schedule for recalibration. For best results when not in use, follow the storage procedures recommended for the various probes described under OXYGEN PROBES AND EQUIPMENT. This will reduce drying out and the need to change membranes.

APPENDIX C

Estimating Minimum Volumes and Sampling Times of Wells

Estimating Minimum Volumes and Sampling Times of Wells

When using Table 2, you may interpolate. As an example, a well is cased from 0' to 185' with 6" casing and from 185' to 245' with 4" casing. The water level is 10' down. Estimate the volume of water and minimum time involved in evacuating the well casing to obtain a representative sample using a 60 gpm pump.

Step 1: Volume of 6" casing from Table I

a) Standing water = Casing length - depth to water
= 185' - 10'
= 175'

b) 5 x Volume

100' in 6" casing = 734 gallons
80' in 6" casing = 587 gallons
5' in 6" casing = 36 gallons

Total Volume = 1,357 gallons

Step 2: Volume of 4" Casing from Table I

a) Standing water = casing length - depth to water
= 60' - 0'
= 60'

b) 5 x Volume

60' in 4" casing = 195 gallons

Step 3: Total Volume

$$\text{Total volume} = \text{Volume}_{6"} + \text{Volume}_{4"}$$

$$\begin{aligned} \text{Total volume} &= 1,387 \text{ gallons} + 195 \text{ gallons} \\ &= 1,552 \text{ gallons} \end{aligned}$$

Step 4: Estimate Minimum Time

$$\begin{aligned} \text{Minimum time} &= \text{Total volume} - \text{Pump capacity gpm} \\ &= 1,552 \text{ gallons} - 60 \text{ gpm} \\ &= 26 \text{ minutes, rounded up} \end{aligned}$$

It is quite likely that it will not be known whether or not a well is stepped. In that case, the time estimation will be greatly over estimated. If the temperature and specific conductivity were being monitored, it would probably be noted that these parameters stabilized long before the estimated minimum time arrived. Under these circumstances sampling could be initiated much earlier than anticipated and considerable time saved.

