

**STANDARD OPERATING PROCEDURE
FOR CALIBRATION, MAINTENANCE, AND USE
OF YSI MULTIPROBES**

**WILLARD SPUR
2011 MONITORING ACTIVITIES**

State of Utah
Department of Environmental Quality
Division of Water Quality

Revision 1
Effective 9/10/2011

Utah Division of Water Quality (DWQ) Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical experts. The primary purpose of this document is for internal DWQ use. This SOP should not replace any official published methods.

Any reference within this document to specific equipment, manufacturers, or supplies is only for descriptive purposes and does not constitute an endorsement of a particular product or service by the author or by DWQ. Additionally, any distribution of this SOP does not constitute an endorsement of a particular procedure or method.

Although DWQ will follow this SOP in most instances, there may be instances in which DWQ will use an alternative methodology, procedure, or process.

REVISION PAGE

Date	Revision #	Summary of Changes	Sections	Other Comments
9/10/2011	1	not applicable	not applicable	Put DWQ quick references into new standardized format, began document control/revision tracking.

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1.0 SCOPE AND APPLICABILITY

This document presents the Utah Division of Water Quality's (DWQ) Standard Operating Procedure (SOP) for the calibration, use, deployment, and maintenance of YSI (YSI Incorporated) 6-Series water quality sondes (YSI, sonde, or multiprobe) during water sample collection. Reliable water quality field readings are an essential part of any water quality monitoring program. Field readings are typically measurements of current water quality conditions at the time of water sample collection. If deployed for longer periods, YSI's can be used to record temporal changes in water quality. Field readings can be stored electronically on the sonde itself or on the 650 MDS Display/Logger (essentially a handheld computer).

This SOP applies to any DWQ monitor (field personnel), non-DWQ cooperators, or volunteers using a YSI multiprobe instrument for water quality sampling. Procedures for the use of other types of multiprobes such as YSI's or In Situ Trolls are discussed in separate DWQ SOPs. For non-DWQ cooperators or volunteers using YSI single-parameter probe instruments, refer to the appropriate user manual.

The information discussed in this SOP is not a substitute for YSI user manuals, training materials, or other technical documentation. Consult the appropriate manual for a complete guide to the proper use, calibration, maintenance, storage, deployment, and troubleshooting of YSI instruments. This SOP is to be used as a reference but the complete user manual should always accompany the YSI operator.

Additional helpful references for multiprobe instrument use:

- *General multiprobe use* - United States Geological Survey's (USGS) Field Manual (Gibs et al. 2007)
- *Long-term deployment of multiprobes* – USGS technical guidance (Wagner et al. 2006)

DWQ utilizes the following YSI equipment models:

Sondes: 6600 V2-4 (4 optical probe ports) and 600 OMS V2-1 (1 optical probe port)

Handheld: 650 MDS Display/Logger

2.0 Summary of Method

YSI's are calibrated at least once daily during use, unless being used for longer-term deployment applications. YSI's are maintained according to a regular maintenance schedule. YSI's are used by DWQ to simultaneously measure pH (standard units), dissolved oxygen (DO) concentration (mg/L), dissolved oxygen (DO) percent saturation (% saturation), specific conductance ($\mu\text{s}/\text{cm}$), temperature (degrees Celsius),

chlorophyll (RFUs and mg/L), and turbidity (NTUs). Readings are recorded on “Trip Sheets” or other field data sheets and also stored electronically on the instrument, downloaded to DWQ’s server and then uploaded to DWQ’s database after a monitoring trip is completed.

3.0 DEFINITIONS

BP:	Barometric pressure
Calibration:	Checking or adjusting (by comparison with a standard of known value) the accuracy of a measuring instrument; calibration errors lead to inaccurate results and measurement bias
Deployment:	Refers to long-term unattended monitoring of water quality parameters using the multiprobe to log data at programmed intervals
DI:	Deionized water
DO:	Dissolved oxygen
mg/L:	milligrams per liter
mm Hg:	millimeters of mercury
Multiprobe:	A multiparameter instrument combining several probes on one piece of equipment, enabling simultaneous collection of several water quality parameters in the field. Measurements may be instantaneous or logged over time.
MSDS:	Material Safety Data Sheet
NTUs:	Nephelometric Turbidity Units
RFUs:	Relative fluorescence units
Sonde:	The portion of the YSI housing the probes and placed into the water
µg/L:	micrograms per liter
µS/cm:	microsiemens per centimeter

4.0 HEALTH AND SAFETY WARNINGS

Field personnel should be aware that hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of sampling, it is recommended that the sampling be rescheduled. If hazardous conditions arise during

sampling, such as lightning, high winds, rising water, or flash flood warning, personnel should cease sampling and move to a safe location.

Always use caution when operating a multiprobe from a bridge or boat and take appropriate actions to make the situation as safe as possible; suspend the sampling if conditions are unsafe.

Wear gloves or be sure to wash hands after sampling, especially when sampling wastewater discharges or ponds, lagoons, or other potentially contaminated sampling points at regulated facilities.

Use caution if a probe is broken during use – exposed parts may include sharp and broken glass and wires.

When loosening removable parts from a multiprobe, point the instrument away from your body and other people. Pressure may build up under the removable parts, causing them to disengage with force, potentially causing bodily harm.

Pressure from waste gas produced by batteries in the sonde is vented by a pressure-release valve. Do not cover this valve by painting over it and do not disassemble this valve. If this valve is not able to perform properly, waste gas in the battery compartment could build up and cause the sonde to shatter into projectiles that could cause bodily harm.

Calibration standards are generally safe but skin contact should be avoided as a precaution. Also, avoid skin contact and inhalation of potentially hazardous solutions used for equipment cleaning such as isopropyl alcohol. Consult the MSDS for each solution used to become aware of any potential hazards.

5.0 CAUTIONS

The instructions in this SOP and in the applicable YSI user manual must be followed by all field personnel to avoid damage or loss of expensive equipment.

Use the supplied probe guard to protect the probes on the sonde during use. Failure to cover the probes with the probe guard could result in irreparable damage to the probes.

Always store the sonde properly: Between sampling sites, fill the plastic calibration cap covering the probes with a very small amount of tap water or environmental water (no more than ½ inch) to keep the probes moist. If stored improperly for short periods of time (between sampling sites), the YSI may give inaccurate readings or drift. If stored improperly for long periods of time (the probes are allowed to dry out completely), the probes may be irreparably damaged.

Use caution when suspending the YSI from a bridge; be observant of debris coming from upstream that may damage the sonde or become entangled in the cable.

Take care when storing the YSI in the field vehicle to ensure it is safe from breakage during transport.

When changing the sonde batteries, consult the detailed instructions in the user manual. Failure to install the battery lid correctly can result in water leakage into the battery compartment. Also, remove the sonde batteries before short or long-term storage; leaking battery acid can damage equipment.

It is recommended that the YSI sonde not be exposed to extreme temperatures below -40°C or above 60°C. The pH and optical sensors should not be exposed to temperatures below -10°C or above 60°C.

6.0 INTERFERENCES

The YSI must be properly calibrated to ensure accurate results.

Inaccurate readings may result if the YSI is lowered into bottom sediments versus the water column/open water. Also, collect readings after any disturbed sediments have been cleared by the current. When sampling wetlands or other slow-flowing or non-flowing water bodies, it is essential to reach out into the waterbody away from the bottom sediment stirred up when wading to the sampling point to ensure an accurate reading of field parameters. Alternatively, lower the sonde from a boat in these situations.

7.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

Field personnel are required to read this SOP annually and acknowledge they have done so via a signature page (see **Appendix 1**) that will be kept on-file at DWQ along with the official hard copy of this SOP.

Personnel collecting field readings must be familiar with YSI calibration and use, safety procedures, proper handling, and record keeping. Monitors are responsible for attending refresher meetings held each spring to review calibration procedures and use. New staff will be trained in the field by experienced personnel.

The procedures discussed in this SOP can change over time as a result of the technological changes being implemented; such information generally is available from the manufacturer, either online or in an updated user manual or other technical guidance document. Monitors operating YSIs must stay current as to how their instrument operates and is maintained.

8.0 EQUIPMENT AND SUPPLIES

- ___ Copy of this SOP
- ___ Site portfolio
- ___ Copy of project-specific SAP

- ___ YSI Sonde binder (containing calibration sheets and maintenance/repair logs)
- ___ Field sheets/field notebook
- ___ Water-proof pens/markers
- ___ Maps
- ___ GPS unit
- ___ Camera
- ___ YSI case with YSI sonde, handheld, cable of appropriate length, and power charger
- ___ Extra batteries for sonde (8 C-size alkaline batteries)
- ___ Another YSI to be used as a back-up
- ___ Maintenance tool kit
- ___ YSI calibration cup and cap
- ___ YSI probe guard
- ___ Tap water
- ___ DI (deionized) water (carboys, half-gallon jugs, and squeeze bottles)
- ___ pH calibration standard solution (also called buffer) at pH 7 and 10, temperature correction chart and expiration date for buffers, if not printed on the bottle
- ___ pH SRM (Standard Reference Material) or other certified pH standard to check calibration
- ___ Conductivity calibration standard solutions (2 values, one must be ≥ 1 mS/cm)
- ___ Bubbler apparatus to stay in the lab/DWQ Shop (aquarium air pump with a bubbler stone, container of tap water at room temperature)
- ___ Bubbler apparatus to take into the field (aquarium air pump with a bubbler stone, power inverter, 5 gallon bucket, tap water)
- ___ Lint-free cloth (such as Kimwipes)
- ___ Cooler
- ___ Ice
- ___ Safety gear
- ___ Chest waders with belt or hip boots

9.0 PROCEDURE

9.1 Pre-Sampling Trip Preparation

- 1) Review the project-specific SAP or consult the Project Manager to confirm the sampling locations and the targeted sampling conditions.
- 2) Coordinate with other monitors/users to make sure equipment is available for use.
- 3) Check the battery life of the sonde and handheld to be used and replace batteries if needed.
- 4) Obtain any necessary permission for site access.

9.2 Calibration

In order to ensure reliability of readings, the instruments are calibrated each morning prior to sampling and at any time during the day that a reading may be considered questionable.

For calibration solution re-ordering purposes, the YSI manual provides recommended volumes of calibration reagents per calibration, depending on the orientation of the sonde during calibration, and depending on the probe being calibrated.

It is recommended to use the calibration cup provided with the YSI. If calibration is to be performed in some other container such as lab glassware, be sure to place probe guard on the sonde before calibration and use a ring stand and clamp to protect the probes from damage during calibration.

Ideally choose pH calibration standards that are close to or bracket values expected in the field; this is not necessary for specific conductance. To ensure accuracy, do not reuse calibration standards for calibration. However, used calibration standards may be kept and used for the pre-rinses prior to calibration. Just make sure these "rinse" containers are thoroughly labeled.

Buffers and calibration standards should be protected against wide temperature variations, whether in transit, during use, or in storage. The values of buffers that experience extreme heat or freezing temperatures can no longer be assumed to be valid. Discard compromised buffer solutions appropriately and notify the DWQ monitor responsible for purchasing new buffer solutions. Store buffer solutions in coolers while in the field to protect them from extreme heat or cold, if necessary.

Best practice is to calibrate with solutions similar to the temperature of the water to be sampled – this ensures the most accurate results. However, for specific conductance, do not equilibrate the temperature of the conductivity standards to that of the water to be sampled if that water temperature is $< 6^{\circ}\text{C}$ or $> 40^{\circ}\text{C}$. At these temperatures, specific conductance changes significantly as a function of temperature.

Never insert a probe into a buffer stock solution bottle during calibration; pour the buffer solution off into a separate container (calibration cup) before calibration.

Before calibration, inspect the probes and perform any necessary cleaning. Be sure that any ports where probes are not installed have the port plug in place; it is essential to keep these electrical connectors dry. For probes that have wipers, make sure wipers are clean and free of debris before calibration/use. **Never manually rotate wipers.** Replace wipers, wiper pads, and copper tape as needed according to the manual instructions and record these activities in the maintenance log.

Calibration can be conducted with the sonde upright or inverted; this is user preference. Whichever orientation is chosen, it is essential that the probes are completely submersed during calibration.

Do not use a probe that gives “*calibration Error*” or “*Out of Range*” warnings during calibration or use.

Because pH buffer solutions typically have conductivities higher than conductivity standards or environmental waters, the following calibration order is recommended: *specific conductance/thermistor* → *pH* → *chlorophyll-a* → *turbidity* → *optical DO*

YSI suggests that after calibration, the user put the probe guard on and travel to sampling sight with a wet towel wrapped around the guard to keep probes moist during transportation.

9.2.1 Temperature

The temperature probe (thermistor) is factory-calibrated and no adjustment is necessary but accuracy is checked against a NIST (National Institute of Standards and Technology) certified thermometer once per year.

9.2.2 Specific Conductance

For specific conductance, perform a 2-point calibration. Use 2 standard values (the 2 highest standards available at the DWQ shop) for calibration and perform the “0” in air as a check that the probe is functioning properly. Start calibration with the lowest standard and follow with the highest standard. YSI does not recommend calibration with solutions less than **1 mS/cm** due to potential contamination issues with these lower-valued standards. During calibration, fill out the calibration sheet completely and accurately.

- 1) Turn on the 650 MDS Display/Logger and allow it to warm up.
- 2) First prepare the conductivity cell for the “zero” check by rinsing the probe thoroughly with tap or DI water and using lint-free paper towel (such as a Kimwipe) to gently dry both the inside and outside of the conductivity cell. Make sure the 650 MDS Display/Logger displays a specific conductance reading of 0 $\mu\text{S/cm}$. If “zero” check is acceptable, proceed with calibration. If specific conductance does not read “zero”, the probe may need repair or replacement.
- 3) Rinse the probes and calibration cup 3 times with a small amount of the first (lower value) conductivity standard.
- 4) Hold the sonde vertical and fill the calibration cup with fresh conductivity standard solution – at least enough to fill the conductivity cell and cover the thermistor. Tap the calibration cup gently to dislodge any bubbles trapped in the conductivity cell.
- 5) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet.

- 6) From the sonde main menu, select “2-Calibrate”.
- 7) Select “Conductivity” for calibration type, and then select “SpCond”.
- 8) Enter the first calibration solution value in **mS/cm** (even though field readings are displayed in $\mu\text{S/cm}$), press Enter.
- 9) To calibrate, press Enter again once the readings have been stable for approximately 30 seconds.
- 10) You should receive a “Calibrated” message, if not see **Section 9.6**.
- 11) Press Enter to go back to the main Calibrate menu.
- 12) Record the current post-calibration value on the display into the appropriate space on the calibration sheet.
- 13) Empty the calibration cup, rinse the probes and calibration cup in tap or DI water and dry gently with a lint-free cloth.
- 14) Repeat steps 3-13, proceeding with the second (higher-value) conductivity standard.
- 15) Post calibration, perform the following tasks:
 - A. Go to “Advanced Menu”, select “Cal Constants”. Record the conductivity cell constant value. Acceptable range is 5.0 ± 0.45 . A value out of range indicates either a calibration standard error or that the probe needs to be replaced.
 - B. Use a different conductivity standard solution as a check and record the value the sonde reads into the appropriate space on the calibration sheet. Rinse the calibration cup and probes 3 times with the third solution before performing the check. The “check” conductivity solution should measure within **5%** of the expected value. If sampling involves compliance or potential legal issues, use a certified SRM for this check and record the results appropriately on the calibration sheet. If the “check” buffer or SRM does not fall within the 5% criteria limits, recalibrate for specific conductance. If after testing or replacing the buffers, acceptable calibration cannot be achieved, maintenance or repair of the instrument may be required.

9.2.3 pH

In most cases, pH 7 and pH 10 buffers will be acceptable. If a low pH is expected in the field, calibrate with pH 4 and pH 7. Always start calibration with the pH 7 buffer. During calibration, fill out the calibration sheet completely and accurately. Some pH probes do not have a plastic guard and glass bulbs break easily, use caution when handling.

- 1) Turn on the 650 MDS Display/Logger and allow it to warm up.
- 2) Remove the probe guard if attached.
- 3) Rinse the probes and calibration cup 3 times with tap or DI water. Shake dry or use a lint-free cloth to dry gently.
- 4) Rinse the probes and calibration cup 3 times with a small amount of the pH 7 buffer solution.
- 5) Hold the sonde vertical and fill the calibration cup with fresh pH 7 buffer solution – at least enough to cover the pH probe and the temperature probe. Allow at least 1 minute for the temperature of the pH buffer to stabilize.
- 6) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet. Also record the pH mV value displayed on the screen into the appropriate space on the calibration sheet.
- 16) From the sonde main menu, select “2-Calibrate”.
- 17) Select “ISE1 pH” for calibration type, and then select “2- 2-Point”.
- 18) Enter in the first pH buffer value and press Enter. **Note:** *The actual pH value of all buffers is somewhat variable with temperature and the correct value from the bottle label for your calibration temperature should be entered for maximum accuracy. For example, the pH of YSI’s “pH 7 Buffer” is 7.00 at 25°C, but 7.02 at 20°C.*
- 19) To calibrate, press Enter again once the readings have been stable for approximately 30 seconds.
- 7) You should receive a “Calibrated” message, if not see **Section 9.6**.
- 8) Record the current post-calibration value on the display into the appropriate space on the calibration sheet.
- 9) Press Enter again to “Continue” and proceed to the next pH buffer (either the 10 or the 4 buffer).
- 10) Repeat steps 3-8 for the second pH buffer.
- 11) Empty the calibration cup.
- 12) Rinse the probes 3 times with DI water and then follow steps 4 through 16 for the next pH buffer.
- 13) Empty the calibration cup, rinse the probes and calibration cup with tap or DI water and dry gently with a lint-free cloth.

14) Post calibration, perform the following tasks:

- A. On the calibration sheet, calculate the difference in mV values between pH buffer 7 and 10. A calculated difference < 155 mV indicates that the sensor needs to be replaced.
- B. Use a third pH buffer as a check and record the value the sonde reads into the appropriate space on the calibration sheet. Rinse the calibration cup and probes 3 times with the third buffer before performing the check. The third “check” pH buffer should measure within 5% of the expected value. If sampling involves compliance or potential legal issues, use a certified SRM for this check and record the results appropriately on the calibration sheet. If the “check” buffer or SRM does not fall within the 5% criteria limits, recalibrate for pH. If after testing or replacing the buffers, acceptable calibration cannot be achieved, maintenance or repair of the instrument may be required.

9.2.4 Chlorophyll

The chlorophyll probe measures RFUs and translates those readings into µg/L. Because the chlorophyll probe is not calibrated to a µg/L standard and lab analyses determining µg/L of chlorophyll-a from a processed sample are very different from a field sensor determining fluorescence of unprocessed environmental water, these displayed concentrations are likely to be inaccurate and are only semi-quantitative. Therefore, always collect at least 1 water column sample for chlorophyll-a when performing an instantaneous chlorophyll field reading, and collect at least 2 water column samples for chlorophyll-a when deploying and retrieving sondes for unattended readings. The analyzed sample results will be compared to the probe readings and field data will be corrected by the project manager, if necessary. See DWQ’s SOP for the Filtering of Chlorophyll-a Samples and DWQ’s SOP for the Collection of Water Chemistry Samples.

DWQ performs a one-point calibration for chlorophyll at a value of “0” µg/L.

- 1) Turn on the 650 MDS Display/Logger and allow it to warm up.
- 2) Remove the probe guard and screw the calibration cup on. Be sure to use a calibration cup with a black bottom.
- 3) Rinse the probes and calibration cup 3 times with DI water. Shake dry or use a lint-free cloth to dry gently.
- 4) Hold the sonde vertical (in the upright position – probes facing down) and fill the calibration cup with clear DI water.
- 5) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet.

- 6) From the sonde main menu, select “2-Calibrate”.
- 7) Select “Optic X-Chlorophyll” for calibration type, then select “Ch µg/L”, and then select “1-1 point”.
- 8) At the prompt, enter in the value of 0 µg/L and press Enter.
- 9) Activate the wiper 1-2 times by pressing “3-Clean Optics” to remove any bubbles from the sensor.
- 10) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet.
- 11) To calibrate, press Enter again once the readings have been stable for approximately 30 seconds.
- 12) You should receive a “Calibrated” message, if not see **Section 9.6**.
- 13) Follow prompts to go back to the main menu.
- 14) Record the current post-calibration value on the display into the appropriate space on the calibration sheet.
- 15) Empty the calibration cup, rinse the probes and calibration cup in tap or DI water and dry gently with a lint-free cloth.

9.2.5 Turbidity

9.2.5.1 1-point

DWQ uses a one-point calibration for routine purposes. The probe is calibrated to “zero” using DI water as the calibration solution. You must make sure the calibration cup has a black bottom.

- 1) Turn on the 650 MDS Display/Logger and allow it to warm up.
- 2) Remove the probe guard and screw the calibration cup on. Be sure to use a calibration cup with a black bottom.
- 3) Rinse the probes and calibration cup 3 times with DI water. Shake dry or use a lint-free cloth to dry gently.
- 4) Hold the sonde vertical (in the upright position – probes facing down) and fill the calibration cup with clear DI water. Do not screw on the calibration cup, rather hold the probes within the cup (a ring stand is best for this procedure).

- 5) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet. If the reading won't stabilize, manually raise the height of the probe from the bottom of the calibration cup until you get the lowest reading observed; the cup bottom may be interfering with the reading. The probes likely need to be at least 2.5 inches above the cup bottom.
- 6) From the sonde main menu, select "2-Calibrate".
- 7) Select "Optic X-Turbidity-6136" for calibration type, and then select "1-1 point".
- 8) At the prompt, enter in the value of 0 NTU and press Enter.
- 9) Activate the wiper 1-2 times by pressing "3-Clean Optics" to remove any bubbles from the sensor.
- 10) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet.
- 11) To calibrate, press Enter again once the readings have been stable for approximately 1 minute.
- 12) You should receive a "Calibrated" message, if not see **Section 9.6**.
- 13) Follow prompts to go back to the main menu.
- 14) Record the current post-calibration value on the display into the appropriate space on the calibration sheet.
- 15) Empty the calibration cup, rinse the probes and calibration cup in tap or DI water and dry gently with a lint-free cloth.

9.2.5.2 2-point

DWQ uses a two-point calibration for regulatory purposes or when accurate readings are required in the low range because low turbidity readings are expected in the field. Refer to a project-specific Sampling and Analysis Plan or contact the Project Manager to determine if a two-point calibration is needed.

A two-point calibration requires specially formulated commercial standards (either formazin prepared according to Standard Methods, dilutions of 4000 NTU formazin concentrate purchased from Hach Company, Hach StablCal standards in various NTU denominations, or AMCO-AEPA standards prepared by YSI). One standard must have a value of "zero" and this standard must be calibrated first. The second standard is typically a value of 126 NTUs.

You must make sure the calibration cup has a black bottom. Be sure not to agitate standards while handling. Pour standards into the calibration cup very carefully in a manner that does not introduce any air bubbles.

Retain these expensive standards after calibration in a marked bottle to be used for rinsing during future calibrations. But always use fresh standard for the calibration itself.

- 1) Turn on the 650 MDS Display/Logger and allow it to warm up.
- 2) Remove the probe guard and screw the calibration cup on. Be sure to use a calibration cup with a black bottom.
- 3) Rinse the probes and calibration cup 3 times with DI water. Shake dry or use a lint-free cloth to dry gently.
- 4) Rinse the probes and calibration cup 3 times with a small amount of the turbidity standard to be used for calibration.
- 5) Hold the sonde vertical (in the upright position – probes facing down) and fill the calibration cup with the 0 NTU turbidity standard. Pour the standard down the side of the cup so as not to introduce any air bubbles.
- 6) Turn the lights off; continue calibration of the “zero” standard in the dark.
- 7) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet. If the reading won’t stabilize, manually raise the height of the probe from the bottom of the calibration cup until you get the lowest reading observed; the cup bottom may be interfering with the reading. The probes likely need to be at least 2.5 inches above the cup bottom.
- 8) From the sonde main menu, select “2-Calibrate”.
- 9) Select “Optic X-Turbidity-6136” for calibration type, and then select “1-1 point”.
- 10) At the prompt, enter in the value of 0 NTU and press Enter.
- 11) Activate the wiper 1-2 times by pressing “3-Clean Optics” to remove any bubbles from the sensor.
- 12) Once the reading has stabilized, record the current value on the display into the appropriate space on the calibration sheet.
- 13) To calibrate, press Enter again once the readings have been stable for approximately 1 minute.
- 14) You should receive a “Calibrated” message, if not see **Section 9.6**.

- 15) Record the current post-calibration value on the display into the appropriate space on the calibration sheet.
- 16) Press Enter again to Continue and proceed to the next turbidity standard.
- 17) Repeat steps 4-15 with the second (non-zero) turbidity standard.
- 18) Empty the calibration cup, rinse the probes and calibration cup in tap or DI water and dry gently with a lint-free cloth.

9.2.6 Optical Dissolved Oxygen

This probe is calibrated by immersing the probe into a container of tap water which has been saturated with air by an air pump with a bubbler stone and then calibrating to the local corrected BP.

- 1) Plug in the air pump upon arriving to the shop. Let the pump run while calibrating for the above probes. Bubbler should be running for at least 10 minutes before beginning DO calibration. If the water container is low on water, refill it with water stored in the quart container sitting next to it on the counter. Be sure to refill the container used to store water with tap water. Water used for calibration needs to sit for at least 12 hours to allow the water temperature to stabilize to room temperature. Changes in water temperature while calibrating will cause errors in the calibration results. If water temperature changes more than 0.5°C during calibration, it is recommended to recalibrate the probe.
- 2) After the water is sufficiently aerated unplug the pump and submerge the probe into the container. If the pump is left on oversaturation will occur and cause errors in the calibration results.
- 3) Immerse the probe in the container of water. Watch the ODO display on the Surveyor and proceed with calibration after the DO and temperature readings have stabilized.
- 4) From the sonde main menu, select "2-Calibrate".
- 5) Select "ODOSat%" and then select "1 point". Calibration in the DO% mode also results in calibration of the DO mg/L mode.
- 6) Enter the barometric pressure (BP) in mm hg and press Enter. The YSI 650 MDS Display/Logger has a built-in barometer. Also record the BP on the calibration sheet. If a barometer is not available, local corrected BP can be estimated from the equations in **Appendix 2** of this SOP.

- 7) The current values of the sensors will appear on the screen. Once the DO and temperature readings have stabilized, record the current value on the display into the appropriate space on the calibration sheet.
- 8) Record the current value on the display into the appropriate space on the calibration sheet.
- 9) To calibrate, press Enter again once the readings have been stable for approximately 30 seconds.
- 10) You should receive a “Calibrated” message, if not see **Section 9.6**.
- 11) Record the current post-calibration value on the display into the appropriate space on the calibration sheet. Note: At the DWQ Shop elevation, %DO at 100% saturation will calibrate to approximately 86%. Recalibrate if this value is not achieved.
- 12) Post calibration, perform the following tasks:
 - A. Go to “Advanced Menu”, select “Cal Constants”. Record the DO Gain value. Acceptable range is 0.7 to 1.4. A value out of range indicates that the probe needs to be replaced.

Field Re-Calibration: Ideally another entire bubbler apparatus should be taken into the field with sampling crews to perform field calibrations if needed. Field calibrations should be performed on site if the elevation where sampling occurs is different than the elevation at which the DO was calibrated before leaving for the field. If a bubbler apparatus is not available tap water can be air-saturated by filling a $\frac{1}{2}$ gallon container with tap water stabilized to the outside temperature and vigorously shaking it for 40 seconds. Calibrate the probe in a shaded area so heating of the water from the sun does not affect the calibration results.

9.3 Routine Field Use (Discrete Readings)

- At the sampling site, remove the calibration cup, attach the probe guard, and turn on the Surveyor to allow it to warm up.
- Set up the run file: Select 1-Discrete Sample from the Run menu. Select 3-File to enter a filename. Enter the file name as the Trip ID. You may also select 4-Site Name to enter the site description. Select 1-Start sampling to start discrete sampling.
- Position the sonde in the waterbody. The YSI sonde may be positioned in the waterbody to be sampled using the following methods:
 - Wading into a flowing waterbody and positioning the sonde in the thalweg

- Positioning the sonde in water along a bank/edge (preferably a location with good flow) if waterbody cannot be waded
- Lowering the sonde into a waterbody from a bridge or a boat
- Whatever method is chosen, be sure to use a cable of appropriate length, place the sonde in water that is well-mixed whenever possible, avoid laying the sonde in bottom sediments or between large rocks on stream bottoms, and allow the sonde to orient itself to the flow (probes will face downstream in a flowing waterbody).
- While the readings stabilize, look over the water quality readings displayed on the YSI to make sure they fall within acceptable limits. Recalibration of the YSI may be needed if any parameters are exceeding. The following are a list of parameter exceedances:
 - Dissolved oxygen: Greater than 100% saturation
 - pH: Values less than 6.5 or greater than 9.0
 - Specific conductance: Values greater than 10 times or less than 1/10 the standard used for calibration
- If readings for optical probes are not stabilizing, select “3-Clean optics”. Once the readings have been verified by the operator and all parameters have stabilized, select “1-LOG” last sample to store the readings. Make sure you see the following message flash across the top of the screen: “Sample logged”.
- Be sure to safely store the YSI in the field vehicle for transport between sites. Also, replace with probe guard with a calibration cup containing a small amount (1/2 inch) environmental water or tap water, to ensure probes do not dry out between sites. Do not store the probes in DI water between sites and do not allow any storage medium to freeze around the probes. Store smaller sondes that have fewer probes with the black cap and damp sponge inside the cap.

9.4 Deployment (Unattended Readings)

Consult the project-specific Sampling and Analysis Plan or the Project Manager for where sondes should be located, the duration of deployment, and the frequency of measurement collection during deployment. In general, each deployed sonde should be outfitted with a “Property of DEQ” tag, should be placed in a location of flowing water (except for lake monitoring), and should be placed, if possible, in a location that minimizes potential damage from floating debris and vandals. In addition, sondes for deployment may be outfitted with copper alloy tape and parts, ¼-inch plastic mesh, or saran wrap with electrical tape (or any combination of the three) to reduce fouling and exposure to small animals and debris.

The YSI sondes can be programmed for an unattended sampling run from the 650 MDS Display/Logger or a PC. Typically, a sampler deploys or retrieves multiple sondes on the same day. To check for probe drift, the sampler should gather all the sondes, put them in the same body of water, and collect about 5 readings (according to the logging frequency). This should be done before sondes are deployed and again when they are retrieved. The project manager may choose to use this information to perform a correction on the data for one or more sondes. Sondes can also be checked at the DWQ Shop against calibrations standards, if required in the project-specific Sampling and Analysis Plan. Record any post sample measurements taken in the sonde's three-ring binder.

Calibration:

The YSI probes should be calibrated before programming an unattended sampling run. If calculating DO on site, wait until after final calibration to program the sampling run.

Programming with the Handheld 650 MDS Display/Logger:

- Turn on the MDS handheld and select “Sonde Menu” from the Main Menu. “Sonde Menu” accesses the sonde’s interface. If the MDS does not show a “connected” on the screen then the MDS cannot communicate with the sonde. This usually occurs when the cable connections are not secure or the batteries that power the sonde need to be replaced.
- From the Sonde Main Menu select “Run” then “Unattended Sample”. From this menu you have several options to choose from to customize your sampling run.
 - Interval: controls the amount of time between samples
 - Start Date: Runs can either be started immediately or delayed to a specified date.
 - Start Time: Runs can either be started immediately or delayed to a specified time. **Note:** Sondes with 3 optical probes or 1 optical probe will sample ~1:10 and 0:32 seconds after the specified start time, respectively.
 - Duration: Set the number of days the sonde is going to record.
 - File: The file name the downloaded data will be given. It is recommended that you use a STORET number or the probe name and date and record probe location in a field notebook.
 - Site: Additional information about sonde location. Other important information can be recorded such as sonde name or site description.

- Battery Life: Battery life is a function of the sampling interval and battery volts. Battery Life will adjust on the fly as sampling interval is changed.
- Free Memory: This value represents how many days the sonde can record at the current sampling interval. Free memory will adjust on the fly as sampling interval is changed.
- Start Logging: Selecting this will save the sampling information and begins the logging process. If a delayed start has been selected above the sonde will automatically start logging at that start date and time.

Programming with PC:

- Need to have Ecowatch software installed on your computer.
- Need connector “Y” cable to connect sonde cord to a 9 prong connection.
- Once Ecowatch is open and you select your port, look at the toolbar and select the “dynamite” icon (supposed to resemble a sonde but looks like a stick of dynamite).
- At the main menu of Ecowatch you should see a “#” sign. This indicates that software is connected to the sonde.
- Type “menu” after the “#” sign to communicate with the sonde main menu. From here all steps are the same as above for the Handheld.

9.5 YSI Data Download

- Must have Ecowatch software downloaded on computer. Ecowatch is on the DWQ Shop computer or you can install the software on any other computer.
- Plug YSI into computer port using the adaptor cord. Ecowatch gives you the option to select any port on the computer.
- Once Ecowatch is open and you select your port, look at the toolbar and select the “dynamite” icon (supposed to resemble a sonde but looks like a stick of dynamite).
- If the program reads the sonde the pound “#” sign will appear.
- If the “#” sign does not appear check the following:
 - All connections from the sonde to the computer are secure
 - That you have selected the right port that the sonde is plugged into

- The sonde may be out of battery. There is an adapter to attach to the computer cord that you can plug into the wall.
- Type “menu” after the “#” sign. This will connect you to the sonde’s menu. This is analogous to selecting “sonde menu” on the MDS.
- Select option 3 (file) and choose “Upload” (to choose file to upload) or “Quick Upload” (to upload the last file).
- Select PC6000 as download format. This will download as an Ecowatch .dat file. The advantage of this file is that it will download all of the data stored on the sonde including diagnostic information. **It is highly recommended you download and save this file.**
- Save the .dat file as a unique name (most likely STORET & Date).
- Open the file you just downloaded.
- Select the spreadsheet tab from the toolbar. This will allow you to see all of the data that will be exported on your final file.
- To modify parameters you want to export go to setup>parameters>add/remove. Add or remove any parameters you want to export.
- Go to file>export>CDF/WMF to export as a comma delimited file. Name the file accordingly.
- Be sure to save and transfer the .dat and the .cdf file.

9.6 Troubleshooting and Part Repair/Replacement

- If a YSI sonde, probe, or handheld needs repair or a replacement part, contact the DWQ vendor or the general YSI contacts. The DWQ vendor can get replacement parts to DWQ very quickly in an emergency. YSI vendor contact info is also located in the three-ring binder accompanying each sonde.

DWQ Vendor: Randy Hadland
Northwest Regional Manager
SonTek/ YSI *environmental*
Office: (360) 915-7331
Cell: (360) 870-5935
Email: rhadland@ysi.com

Main Line: **SonTek/YSI**
9940 Summers Ridge Road
San Diego, CA 92121-3091

Telephone: +1-858-546-8327
FAX: +1-858-546-8150

Email
General: inquiry@sontek.com
Support: support@sontek.com

- If a calibration fails, check that calibration standards are within expiration dates and have been stored properly. If problems with calibration standards are not suspected, attempt to recalibrate. If the calibration fails a second time, clean the probe and repeat the calibration. If calibration fails again, the probe likely needs maintenance or repair.
- If the handheld display shows a warning message, do not use the probe until the error has been identified and corrected.
- Consult the YSI vendor contact information located in the three-ring binder accompanying each sonde for replacement parts.
- Consult the YSI user manual Section 6 Troubleshooting assistance. **Appendix 3** of this SOP also includes some troubleshooting tips for multiprobe instruments.

9.7 Cleaning, Maintenance, and Storage

- Each sonde, when taken into the field, should be accompanied by a maintenance tool kit.
- For battery replacement instructions, refer to the user manual.
- Consult the user manual for detailed instructions on cleaning, maintenance, and storage for YSI's and the individual probes. The user manual also gives tips for rehydrating probes if they accidentally dry out.
- **Short-term storage** is storage lasting only **one to three weeks**. Store the probes on the sonde with the calibration cup screwed on and filled with a small amount of tap water (1/2 inch) in the bottom of the cup. Alternatively, a moistened sponge may be placed in the bottom of the cup. This maintains a water-saturated atmosphere and keeps the probes moist. Do not allow the storage solution to freeze around the probes.
- **Long-term storage** is storage lasting **one month or longer**.
 - **YSI 6600V2-2:** Leave the conductivity/temperature and the dissolved oxygen probes in the sonde with a membrane cap and moistened sponge on the optical DO sensor. Remove all other probes from the sonde and store according to the instructions below. Cover all empty probe ports on

the sonde with the provided plugs. Fill the calibration cup with enough tap water to cover the remaining sensors, and tighten the calibration cup onto the sonde to attain a good seal and prevent evaporation. Do not allow the storage solution to freeze around the probes. If the sonde has batteries in it used for long term deployment, remove the batteries during long term storage.

- **pH:** Place the probe in the storage vessel (plastic boot or bottle) which was in place on delivery. The vessel should contain a 2 molar potassium chloride solution, or pH 4 buffer.
- **Turbidity and Chlorophyll:** Place the sensor back in the storage boot that was provided (with no solution added), and set aside in room air.
- **YSI 600 OMS V2-1:** Store the sonde dry with the optical probe left in the port. Cover the membrane on the optical sensor with a cap and moist sponge.
- **Cable storage:** Store the cables in coils of at least 6" or larger. Never knot cables.
- When changing out a sensor, make sure to remove the sensor with the sonde upright (sensors at bottom) so that water does not get down into the electrical port. If port is wet, dry with a kimwipe, canned air, or alcohol. Also be sure to keep the cable connector port covered and dry.
- Check the condition of o-rings on the sonde weekly during regular use. O-ring seals must be maintained to prevent water from entering the battery compartment and sensor ports. If o-rings need cleaning, greasing, or replacement, refer to the user manual for detailed instructions.
- Each probe on a sonde should be inspected before calibration and deployment. Maintenance and cleaning, if needed, should be performed at the same time. Maintenance and cleaning is the responsibility of the user/calibrator.
 - **Thermistor:** Keep the thermistor clean and shiny.
 - **Specific Conductance (conductivity probe):** Brush the conductivity electrode with a pipe cleaner prior to each calibration – keep it very clean. Mild soap and water may be used during cleaning.
 - **pH:** Cleaning is required is deposits or contaminants are visible on the glass or platinum surfaces or when the probe response becomes slow. Cleaning options for the sensor include soap and water, a 50% bleach soak for 30 minutes, a 1.4 M HCl soak for 30

minutes, or q-tips with a foam pad. Clean gently because the pH probe glass electrode can be easily broken. Change out this sensor every 1.5 years or sooner if the mV reading indicates the probe needs replacement.

- o **Turbidity and Optical Chlorophyll:** Keep the face, window, and outside of probe clean, using a moistened kimwipe for cleaning. The wiper pads should be changed when they get dirty. Attach the 1st new pad, then cut off the half overhanging. The shiny part goes inside, the soft part contacts the window. An Allen wrench is used to remove the blades. When reattaching, press down slightly so that the wiper sponge is compressed as you're reattaching wiper to get good contact with window – you should be able to slip a business card under the wiper hardware.
 - o **Optical D.O.:** The sensor membrane should be cleaned only with a kimwipe that has been moistened with water; never use alcohol on this sensor as it will dissolve the black epoxy paint. Scrubbing will also wear off paint. If the black epoxy paint on cap gets worn off, the membrane cap needs to be changed. Change the membrane cap every 1.5 years (timed with pH sensor recommended replacement). Change the membrane cap in the lab, if possible. Wipe under the cap with kimwipes, do not use the silicone lubricant when screwing on the new membrane cap. The new membrane cap comes with cap-specific calibration coefficient values, enter the values during first calibration with the new cap. QA check – “ODO gain” should be ~ 1. Do not store extra membrane caps – purchase them only when needed.
 - o **Barometer:** The barometer on the YSI handheld should be calibrated every 6 months; check against a certified barometer.
- All maintenance activities (such as changing a DO membrane cap, replacing a sensor, replaced wiper blades, etc.) are to be recorded in the three-ring binder that assigned to each sonde.

10.0 DATA AND RECORDS MANAGEMENT

Record all calibration, maintenance, or repair or replacement part service order information in the three-ring binder; there is a unique binder for each YSI sonde.

On the YSI calibration sheet note any problems that arose during calibration or in the field and whether it was resolved or not. If the problem cannot be resolved, the main person responsible for YSI maintenance is to be notified and the YSI calibration sheet with the problem noted on it photocopied and given to them so they can conduct the repairs or have the unit sent off for repair if necessary.

Also note any equipment issues or purchasing needs in the field notes.

Downloaded YSI files are to be saved into the “Monitors” folder in the DWQ shared drive (which is backed up routinely onto DEQ servers). YSI files should be reviewed every 2 weeks by the monitor performing the file download. Once formatted and determined to be complete and accurate, the monitor will upload the YSI data to water quality database staging area. The Database Manager performs an additional review prior to pushing the data into the database for permanent storage.

11.0 QUALITY ASSURANCE AND QUALITY CONTROL

YSIs must be calibrated before use and calibration must be documented as described in this SOP and other project-specific documentation.

Project-specific quality assurance and quality control requirements are described in project-specific Sampling and Analysis Plans (SAPs) and should be communicated to the field team by the Project Manager.

Representative water-quality data is to be collected, according to the sampling conditions required under the project-specific SAP. Multiprobe operators should not alter designated sampling locations or times unless otherwise directed by a project manager. If hydrologic conditions are significantly different from those targeted in the SAP, operators should contact the project manager for further instructions. Operators should record in field notes any site conditions that may lead to an unrepresentative field reading and should take site photographs to record these observations.

12.0 REFERENCES

<http://www.yei.com/resource-library.php> - This site includes manuals, technotes, tips, quick references, and white papers.

6-Series Multiparameter Water Quality Sondes User Manual. YSI Incorporated. Online at <http://www.yei.com/media/pdfs/069300-YSI-6-Series-Manual-RevF.pdf> (accessed September 9, 2011).

Gibs, Jacob, Wilde, F.D., and Heckathorn, H.A., 2007, Use of multiparameter instruments for routine field measurements (ver. 1.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, section 6.8, August, available only online at <http://water.usgs.gov/owq/FieldManual/Chapter6/6.8.html>.

Swanson, T. 2010. Standard operating procedures for Hydrolab DataSonde[®] and MiniSonde[®] Multiprobes. Washington State Department of Ecology Environmental Assessment Program. Version 1.0.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., Smith, B.A. 2006. Guidelines and standard procedures for continuous water-quality monitors; Station operation, record

computation, and data reporting (ver. 1.0): U.S. Geological Survey Techniques and Methods 1 - D3, 96 p., available only online at <http://pubs.usgs.gov/tm/2006/tm1D3>.

Wilde, F.D., editor. Variousy-dated. Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, with sec. 6.0–6.8, accessed at <http://pubs.water.usgs.gov/twri9A6/>.

Appendix 2 – Estimating Local Barometric Pressure (taken directly from Hach LDO Probe Instruction Sheet)

Determine the barometric pressure for entry as the calibration standard. The barometric pressure needs to be in mmHg. 1mmHg = 0.00133322 bar = 133.322 pascal = 0.019336778 pounds/square inch [absolute].

Local Barometric Pressure, BP, in mmHG can be estimated using:

$$BP' = 780 - 2.5(A_{ft}/100) \text{ or } BP' = 780 - 2.5(A_m/30.5)$$

where:

BP' = Barometric pressure at altitude

BP=Barometric pressure at sea level

A_{ft} = Altitude in feet

A_m = ALtitude in meters

If using the local weather bureau BP, remember these numbers are corrected to sea level. To calculate the uncorrected atmospheric pressure BP', use the following equations:

$$BP' = BP - 2.5(A_{ft}/100) \text{ or } BP' = BP - 2.5(A_m/30.5)$$

where:

BP' = Barometric pressure at altitude

BP=Barometric pressure at sea level

A_{ft} = Altitude in feet

A_m = ALtitude in meters

Local barometric pressure in mbar (*BPmbar*) can be converted to local barometric pressure in mmMG (*BPmmHG*) using:

$$BPmmHG = 0.75 \times BPmbar$$

Appendix 3 – Multiprobe troubleshooting tips (Table 6.8-7 from USGS Field Manual)

[DO, dissolved oxygen; NIST, National Institute of Standards and Technology; SC, specific electrical conductance; ORP, oxidation-reduction (redox) potential; Cl, chloride; NH₄, ammonium; NO₃, nitrate; NTU, nephelometric turbidity unit]

Symptom	Possible cause(s), corrective actions, and tips
Erratic or jumpy readings	<ul style="list-style-type: none"> • May be caused by loose connections or sensitivity to the electrical capacitance of your body and to static electricity: avoid touching the sonde housing and try to keep a distance of about 1 meter from the sonde.
Display does not turn on	<ul style="list-style-type: none"> • Check that the batteries are installed properly and are fully charged. • Battery performance decreases with decreasing temperature. Batteries that charge at room temperature may not perform well when the temperature approaches freezing. Carry spare batteries.
The display does not show readings; the readings seem to be wrong	<ul style="list-style-type: none"> • Check that the readings are displayed in the appropriate units. Inspect all connectors for moisture, dirt, damage, or a loose connection. Clean as recommended by the manufacturer. • Disconnect and reconnect and recalibrate the sensors. When replacing sensors, the waterproof and dustproof properties of the instrument must be maintained or instrument performance will degrade.
Data on the display appear scrambled	<ul style="list-style-type: none"> • Check for computer speed and software and hardware compatibility. • Check for a damaged cable. • Check that the correct units are displayed. • If data remain scrambled, consult the manufacturer or authorized service center.
Initial drifting of the readings	<ul style="list-style-type: none"> • Increase the time for sensors to equilibrate to the water temperature. • Check that the sensors are appropriately submerged and (if necessary for the instrument) that they are at the appropriate inclination from the horizontal.
Dissolved-oxygen reading is unstable or inaccurate	<ul style="list-style-type: none"> • Check that the sensor has been calibrated to the true onsite barometric pressure or altitude; recalibrate the sensor at the proper barometric pressure and, to the extent possible, with calibrants brought to sample temperature. • Amperometric DO method: Inspect the membrane for a puncture, bubbles, or improper installation. Verify the integrity of the membrane, electrolyte solution, and O-ring by checking the reading against a zero-DO solution. Rinse the sonde thoroughly.
Temperature reading is unstable or inaccurate	<ul style="list-style-type: none"> • Check for water in the connector; dry the connector and reinstall the sensor. • Check the accuracy of the reading with an NIST-traceable thermometer and have it replaced if necessary. Usually, only the manufacturer can replace a faulty thermistor.
Reading is unstable or inaccurate for SC, pH, ORP, turbidity, Cl, NH ₄ , or NO ₃	<ul style="list-style-type: none"> • Examine the sensor for dirt or damage. Clean dirty sensors according to the manufacturer's instructions. Replace damaged sensors and recalibrate. • Ensure that the temperature reading is accurate by allowing sufficient time for the temperature sensor to equilibrate to the water temperature. • Check that the calibration solutions used for SC, pH, and ORP were not expired or subject to contamination. • Recalibrate the sensor(s), first bringing the calibration solutions as close to the ambient temperature of the sample as is practical, given ambient field conditions. • Check pH reference junction: if dry, follow manufacturer's instructions for soaking the sensor in tap water or buffer solution until readings stabilize. Alternatively, replace the junction. • Check the sensor connector for water; dry the connector and reinstall the sensor. • If the ZoBell check fails, was temperature dependence of the ZoBell solution accounted for? • The SC sensor must be fully immersed for proper calibration and sample measurement. There must be no bubbles in the cell. • The turbidity sensor wiper must be clean, activated, and rotating properly. Check that expired turbidity calibrants were not used, including any diluted 4000-NTU formazin standard (which must be used within 24 hours of preparation).