In situ Water Quality Measurements and Meter Calibration for Lotic Waters Standard Operating Procedure

Commonwealth of Kentucky
Energy and Environment Cabinet
Department for Environmental Protection
Division of Water

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2. Document Revision History

Date of Revision	Page(s) Revised	Revision Explanation
January 1, 2009		New document
September 28, 2009	Page 5	Section 4.6. Added ORP
March 1, 2018	All	Document was thoroughly revised with additional clarification added for calibrating and using the meter in the field. Step-by-step calibration instructions were added. Calibration log was revised and other field sheets removed.

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3. Table of Contents

4. Procedures

4.1 Scope and Applicability

This standard operating procedure covers the calibration and use of multi-parameter and single parameter data sondes for monitoring of *in situ* water quality in streams and rivers. *In situ* water quality parameters may include dissolved oxygen (DO) (EPA 360.1), percent dissolved oxygen saturation (%DO) (EPA 360.1), oxidation reduction potential (ORP), temperature (EPA 170.1), pH (EPA 150.1), specific conductivity (EPA 120.1) and turbidity (EPA 180.1).

4.2 Health & Safety Assertion

Field staff working in and around potentially contaminated surface waters should receive immunization shots for Hepatitis A in accordance with DEP Policy SSE-708. In addition, staff should receive immunizations for Hepatitis B and tetanus. All field staff should also be trained in CPR, First Aid and Blood Borne Pathogens in accordance with DEP Policy SSE-711. At minimum, staff should receive annual OSHA training and annual medical monitoring.

Personal protective equipment (PPE) should be used when sampling in known waters with the potential for adverse health effects, or in unknown waters that have been determined impaired, but the pollutants have not been identified. Examples of PPE that should be worn are: nitrile or latex gloves, chest waders, wading boots and protective eyewear.

All safety data sheets associated with chemicals used for meter calibration and maintenance will be located in a binder in the calibration lab area. Additional safety considerations for laboratory and field work must be reviewed in the latest worksite hazard guidance document.

4.3 Cautions

1. When possible, do not deploy probes directly in riffles. Doing so will cause some results (DO and turbidity) to be less representative of the sampling reach.

2. While most meter display units are water resistant, many are not designed to be submersed in water. Check the user manual for instrument specifications.

3. Calibration standards are intended as single use solutions. Always pour an aliquot into a separate container for use and discard when done. Never reuse aliquots or immerse probes into original standard containers.

4. The primary physical problem in using a specific conductance meter is entrapment of air in the probe chambers, which is indicated by unstable specific conductance values. Air entrapment can be minimized by slowly and carefully placing the probe into the water; after submerging, move it through the water quickly to release any air bubbles.

5. The accuracy of any measurement made with a probe is dependent upon the probe being clean and maintained in good working condition. Always rinse the probes with clean water after each use. Never store a dirty or contaminated sonde.

4.4 Interferences

The U.S. EPA (USEPA 2007) recommends the following order for calibration of a multi-parameter sonde:

1. Specific Conductance
2. pH
3. DO
4. Turbidity

There is no recommended order for the calibration of other parameters.

4.5 Personnel Qualifications / Responsibilities/Demonstration of Capacity

All field staff will meet at least the minimum qualifications for their job classification. Annual field monitoring training will be provided to review field protocols. Training will continue on-the-job and as formal educational opportunities become available.

4.6 Equipment

A list of equipment currently used by KDOW is found in Appendix A. If using monitoring equipment not listed, the measurement accuracy must be greater than or equal to the following specifications:

Temperature:	± 0.15°
Conductivity:	± 1 µS/cm
pH:	± 0.2 pH
DO:	± 2% ≤ 20 mg/L
	± 6% > 20 mg/L
% DO:	± 2 % 0-200% air saturation
	± 6% 200-500% air saturation
Turbidity:	± 1% 0 - 100 NTU
	± 3% 100 - 400 NTU
	± 5% 400 - 3000 NTU
ORP:	± 20 mV

4.7 Step-by-Step Procedure

4.7.1 Instrument or Method Calibration and Standardization

All equipment must be maintained and calibrated according to user manuals, and/or manufacturer specifications at a frequency recommended by or exceeding the manufacturer. At a minimum, DO should be calibrated daily for YSI 556 and Professional Plus meters, while pH and conductivity should be calibrated at least weekly according to the manufacturer's specifications. For permitting compliance monitoring, probes will, at minimum, be calibrated at the beginning of each day of compliance monitoring. Calibration should also take place anytime the sensor is thought to have drifted from calibration. Any deviation from established procedures must be thoroughly explained and supported with appropriate documentation and recorded in all project reports and logs. All equipment manuals shall be kept on file in an established location. Water Quality Branch equipment manuals are located at: V:\DOWWQB\Equipment user Manuals and maintenance log.

Individual logs must be maintained for each piece of equipment requiring regular maintenance and calibration. Each piece of equipment must be recorded with the serial number or unique identifying number in a calibration log (example - Appendix B). All dates, lot numbers, notes and calculations related to maintenance and calibrations must be recorded in the log and kept in a secure location. Logs may be paper-based or kept in an electronic file on a DEP server. Electronic copies of Water Quality Branch logs are located at: V:\DOWWQB\QA\Field Meter Calibration Logs. Local backups should be maintained weekly. When calibrations are performed in the field, make note of the calibration values and update the electronic calibration log when returning to the office.

4.7.1.1 General Calibration Procedures (may vary slightly based on model)

Access the Calibrate Screen

1. Press the **On/off** to display the run screen.
2. Press the **Cal key,** or if using a YSI 556:
    a. Press the **Escape** key to display the main menu screen.
    b. Use the arrow keys to highlight the **Calibrate** selection and press the **Enter** key.

Conductivity Calibration

1. From the **Calibrate Screen** (described above), choose **Conductivity**, press **Enter.** Then highlight **Specific Conductance**, and press **Enter**.
2. Empty pH 4 or tap water storing solution and rinse sensors with **distilled water**. Then rinse the sensor probe and transport cup with a small amount of conductivity standard and then empty the cup.
3. Fill the transport cup with the **appropriate amount** (enough to completely cover the conductivity sensor and vent hole) of the conductivity standard.
4. Carefully immerse the sensor probe into the solution. Gently rotate and/or move the probe up and down to remove any bubbles from the conductivity cell. The sensor must be completely immersed past its vent hole.
5. Use the keypad to enter **1.000 mS/cm** (or 1000 µS/cm is equivalent; this should be what is listed on the bottle at 25°C.) Press **Enter** to display the Conductivity Calibration Screen.

6. Allow at least one minute for temperature equilibration. When the specific conductance value has stabilized (no significant change for 30 seconds) record the pre-calibration value in the calibration log, press **Enter**, and then record the final value in the calibration log.
7. Press **Enter** again to continue and then **Escape** to return to the calibrate menu.
8. Rinse with deionized water.

pH Calibration

1. From the calibrate screen use the arrow keys to highlight **pH.**
2. Press **Enter.** Use arrow keys to select the appropriate **2-point** or **3-point** calibration option if necessary for the meter. Press **Enter.**
    a. Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the water being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
    b. Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.
3. Rinse the clean and dry sensor probe and transport cup with a small amount of **pH 7** buffer and empty cup.
4. Fill the transport cup with the **appropriate amount** (enough to completely cover the pH sensor) of pH 7 buffer and carefully insert probe into cup. Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.
5. Use the keypad to enter the calibration value of the pH 7 buffer **at the current temperature** (found on the bottle.) Press **Enter.**
6. Allow at least one minute for temperature equilibration before proceeding. Once the pH sensor reading is stabilized, record the pre-calibration value in the calibration log, press **Enter**, and then record the final value in the calibration log.
7. Press **Enter** again to continue to the pH Calibration screen.
8. Rinse with **distilled water**.
9. Repeat steps 3 through 8 above using **pH 10 or pH 4** buffer for the second pH calibration point, and a final time with the remaining pH buffer for a 3-point pH calibration.

DO Calibration **–** (**note:** the instrument must be on for at least 10-15 min to polarize a polarographic DO sensor before calibrating.)

1. Fill the transport cup with approximately 1/8” of water, put sensor probe in cup (make sure DO and Temp sensors are NOT immersed in water). Screw only 1 or 2 threads of the transport cup to make sure the sensors are vented to the atmosphere.

2. From the **Calibrate screen** use arrow keys to highlight **Dissolved Oxygen,** press **Enter.** Select **DO %,** press **Enter.**
3. Enter the current **Barometric Pressure** (see DO Calibration Notes in section 4.7.1.2 for directions on finding the BP for meters without an internal barometer). Press **Enter.**
4. Allow approximately 10 minutes for the air in the cup to become water saturated and the temperature to equilibrate before proceeding.
5. When the **DO%** reading stabilizes for at least 30 seconds record the pre-calibration value in the calibration log, press **Enter**, and then record the final value in the calibration log.
6. Press **Enter** again to Continue and then **Escape** to return to the calibrate menu.
7. Press **Enter**. Press **Escape** to return to the main menu. Press the **On/off** to power off.
8. After calibrations are complete fill transport cup with **3 ml (approx. 1/8") of tap water for short term storage** (**NEVER** store sensor with distilled water).

For any additional probes in need of calibration, follow the manufacturer's recommended calibration procedures in the appropriate device's support documents (Appendix A). This includes all ammonium, barometers, chloride, depth, fDOM, nitrate, total algae, and turbidity sensors.

4.7.1.2 Calibration notes

Temperature

Verification of the meter's internal temperature sensor against a National Institute of Standards and Technology (NIST) traceable thermometer is performed annually, but should drift in temperature reading be suspected, verification should be performed prior to any deployment.

Specific Conductance

When calibrating conductivity, specific conductance (temperature compensated conductivity) should always be chosen for the calibration method and the value of the calibration solution in mS/cm (or µS/cm depending on meter) at 25 ^{o} C used for the calibration value.

pH Calibration

The pH buffers used for calibration shall be within the same pH range as the water that is going to be sampled. At minimum, a two-point calibration will be utilized for all pH sensors.

When calibrating pH, the temperature compensated value of the pH buffer should be used. Some meters (i.e. YSI Pro and EXO) have automatic temperature compensation (ATC) and will give you this value on the calibration screen. For meters without ATC (i.e. YSI 556), the temperature compensated value can be located on the buffer container. Round temperature readings to the scale provided on the buffer container. For example, if the temperature of the pH 7 buffer is 21^{o} C, and the container provides a compensation scale of 7.02 at 20 ^{o} C, 7.00 at 25 ^{o} C, and 6.98 at 30 ^{o} C, the pH value entered into the meter should be 7.02 at 20^{o} C (pH 7.0: Fondriest FNBU5007).

After calibration (YSI meters), pH mV range should be as indicated below (never accept an out-of-range value):

- pH 7 mV value Range 0 mV ± 50 mV
- pH 4 pH mV value Range +165 to +180 from 7 buffer mV value
- pH 10 mV value Range -165 to -180 from 7 buffer mV value

Also, calculate the pH probe slope percentage (automatically calculated from pH mv measurements if using WQB calibration logs):

- Record the pH mV from the two different buffer solutions.
- Calculate the difference in mV between the higher buffer value and the lower buffer value.
- Calculate the difference between buffer pH solutions.
- Divide the difference in mV by the difference in the pH units.
- Divide this result by the theoretical maximum (59.2 mV/pH unit @ 25^{o} C) and multiply by 100 to get a percentage value.
- Values between 95 and 105 are acceptable.
- If performing a 3 point calibration, a separate slope will be calculated and recorded for pH 4-7 and pH 7-10.
- pH sensors should be cleaned, reconditioned, or replaced if slopes are outside of this range.

Example:
pH 7 = -17.3 mV and pH10 = -192.6 mV
-192.6-(-17.3) = -175.3
-175.3/(7-4) = -58.4
-58.4/59.2*100 = -98.63 slope

DO Calibration

DO is calibrated in a 100% water-saturated air environment using %DO as the calibration value. To achieve this environment, a small amount of water is placed in the storage cup and then the cup loosely reattached to the probe (engaging only one or two threads). It then takes approximately 10-15 minutes for the storage cup to become completely saturated.

If meters do not have an internal barometer, DO must be calibrated on site. Polarographic DO probes should be calibrated daily. When this and other calibrations are performed in the field, make note of the calibration values and update the electronic calibration log upon returning.

Barometric pressure should be obtained from the nearest meteorological station for meters without internal barometers. Barometric pressure readings that appear in meteorological reports are generally corrected to sea level and must be uncorrected before use. Appendix C provides a correction table for true barometric pressure readings from the Frankfort, KY airport and KDEP central office. The equation to find true barometric pressure is also given in Appendix C.

Meters with internal barometers that compensate for barometric pressure differences do not need to be calibrated with altitude changes.

Many polarographic DO sensors require a 10-15 minute warm-up time before use or calibration in order to polarize the DO sensor; Refer to specific manufacturers' recommendations for warm-up times.

4.7.1.3 Preparation of Conductivity, pH, DO, and Turbidity Standard Solutions

Record all standards received and solutions made in a standards log.

Conductivity Standard

Conductivity solution is obtained from commercial vendors and is not modified for meter calibration. The following standards are utilized by the Water Quality Branch.

1. Calibration Solution for 1000µS: Fondriest FNCS1000 (or equal) 1000µS conductivity standard.

pH Standard

pH buffer solutions are obtained from commercial vendors and are not modified for meter calibration. The following standards are utilized by the Water Quality Branch.

1. Calibration Solution for pH 7.0: Fondriest FNBU5007 (or equal) pH 7.0 buffer.
2. Calibration Solution for pH 10.0: Fondriest FNBU5010 (or equal) pH 10.0 buffer.
3. Calibration Solution for pH 4.0: Fondriest FNBU5004 (or equal) pH 4.0 buffer.

Turbidity Standard

Turbidity standard solutions are obtained from commercial vendors and are not modified for meter calibration.

4.7.2 Instantaneous *In situ* Water Quality Measurements

Instantaneous water quality measurements include any measurements taken by field instruments, such as single- or multi-parameter probes. *In situ* data and field meter inventory ID are recorded on a field sheet, discharge measurement sheet, field notebook or habitat assessment sheet. *In situ* water quality parameters include:

1. Water Temperature
2. pH
3. Specific Conductivity
4. DO
5. % DO
6. Turbidity
7. ORP

Deployment of an *in situ* meter in streams will follow the following procedures:

1. Meter must be inspected before and after use for fouling and must be cleaned / troubleshooted as needed. DO membrane must be checked for bubbles and repaired if needed.
2. Instrument should be placed mid-stream or in the thalweg in a flowing, well-mixed portion of the stream channel.
3. Per 401 KAR 10:031 section 4(e)2, measurements should be collected at mid-depth at sites < 10 feet deep and at representative depths at sites that are > 10 feet deep. Representative depths shall be outlined in project quality assurance documentation.
4. Before taking field measurements, probes must be allowed to equilibrate to the water being sampled per the manufacturer's recommendations.
    a. If parameter readings are still fluctuating after the initial equilibration period, allow the instrument another 1-2 minutes to stabilize. If readings remain unstable, evaluate the location of the probes, and try these steps;
        - Move unit to a different location in stream
        - Examine probes for acceptable operating condition
        - Gently swirl the probes in low flow conditions
        - Change location of probes, e.g. suspend probes vertically in water column.
5. If unable to record data, document on field data sheets.

When parameter readings cannot be measured in-stream, they can be measured in a bucket. The following conditions must be met when measuring from a bucket.

- The bucket must be large enough to allow immersion of the probe.
- The bucket is to be triple rinsed with ambient water at each site prior to collecting a sample.
- The probe must be placed in the bucket immediately before temperature and oxygen levels change.
- The bucket must be shaded from direct sunlight and strong breezes before and during temperature measurement.
- The probe must be allowed to equilibrate before readings are recorded.
- The probe must be gently swirled if equipped with a membrane-based DO probe.

4.7.2.1 Temperature

Water temperatures must represent the temperature of the stream at the time of the observation. Allow readings to stabilize, then read and record the temperature in ^{o} C without removing from the water.

4.7.2.2 pH

Allow the pH probe to equilibrate according to manufacturer's recommendations. Read and record the pH in standard units without removing from the water.

4.7.2.3 DO

Allow the DO probe to equilibrate according to manufacturer's recommendations. Read and record DO in mg/l and %DO without removing from the water.

Some types of probes (i.e. Clark cell) require sufficient flow (~1 ft/s) of water across the membrane to maintain accuracy and precision of DO analysis. If sufficient flow is not present in the stream, and the probe is equipped with a stirrer, turn the stirrer on; however, if the probe is not equipped with a stirrer, physically move the probe in a gentle motion to produce sufficient flow. When taking a DO measurement in a bucket, turn on the stirrer (if equipped), or physically move the probe in a gentle motion. Stirring too vigorously may result in adding oxygen to the water.

4.7.2.4 Specific Conductance

Conductivity probes must be temperature compensated to 25^{o} C and read as specific conductance in µS/cm@ 25 °C. Probes that are not temperature compensated must have a separate temperature measurement recorded. Allow the probe to equilibrate according to manufacturer's recommendations before specific conductance is recorded. Read and record specific conductance in µS/cm without removing from water.

4.7.2.5 Turbidity

In-situ turbidity samples are analyzed in the field using a probe or portable turbidimeter. Sample aliquots for portable turbidimeters may be taken directly from the stream or from an unpreserved sample bottle. Aliquots from unpreserved sample bottle should be well mixed. Follow manufacturer's procedures for measurement. Read and record turbidity in NTU without removing from water.

4.7.2.6 Oxidation-Reduction Potential (ORP)

Allow the probe to equilibrate according to manufacturer's recommendations before ORP is recorded. Temperature affects the stability of the oxidation-reduction potential. Therefore, readings should be taken before temperature can fluctuate. Read and record ORP without removing from water.

4.7.3 Continuous *In situ* Water Quality Measurements

Unattended deployment entails pre-programming and deployment of a water quality data sonde at a specific location to log monitoring data in the absence of observation by a field investigator. Unattended deployments are useful for collecting data at regular intervals over extended monitoring periods. However, since no data are recorded by hand during the deployment, it is critical that the sonde be correctly programmed.

Programming of the sonde must follow the manufacturer's procedures for unattended deployment. The sonde may be programmed in the lab prior to a field study or programmed in the field. Programming of the sonde is typically accomplished either by the sonde's display unit or by computer.

Programming requires input of a start date/time (24 hour), deployment duration, data log filename, and monitoring interval. Programming times should always be input in local time for the study area, unless otherwise noted on the field sheet. The field sheet should include the sonde identifier, the date/time of initial deployment, date/time of retrieval, deployment location, and sonde depth. Similarly, recorded times should be in local time for the study area.

Following EPA guidance (USEPA, 2007), DOW uses the following procedures for sonde deployment for obtaining continuous *in situ* water quality data:

1. Set sonde to record desired parameters (i.e. water temperature, pH, specific conductivity, and DO) at desired intervals (i.e. 15 min., 30 min.), for the desired monitoring period (i.e. 3 days, 7 days). Use the software included with the sonde.
2. Calibrate all parameters prior to deployment, according to user manuals.
3. If there is a high potential for disturbance to units, attach a waterproof card to each unit, with instructions where and who to contact for information on the data unit, and/or 'warning' labels against disturbing the units.
4. Use wire cable and padlocks (for security) to attach the data unit to a permanent structure on the bank (tree, bridge piling) or use rebar or fence-posts sunk into the bank. The sonde can also be placed in a section of PVC pipe with holes drilled through the pipe so that water may flow freely across the sonde.
5. Suspend the sondes in the water column using floats, or set units on rocks or cement blocks, so all sensors are clear of streambed.
6. Deploy sondes in a well-mixed area of the stream, but not directly in riffles, within high velocities, or in highly aerated areas; if deploying in pools or during low discharges, ensure sensors do not touch the bottom of the channel, and water will flow freely around the sensors; if necessary to deploy in high discharges, ensure units are secured to structures and will not contact banks, channel debris, etc.
7. Obtain water grab samples and measure stream discharge at the beginning of deployment and at retrieval of sondes, for all parameters outlined in project specific plans (if applicable to study objectives).
8. Post-calibrate sondes.
9. Download data and file in electronic project folders.

4.7.4 Troubleshooting

To troubleshoot meter errors, refer to the appropriate user manual (Appendix A) or other available resources.

4.7.5 Computer Hardware & Software

Refer to the appropriate user manual (Appendix A) or other available resources.

4.8 Data and Records Management

Records (i.e. field sheets, field notebooks) completed during each sampling event are maintained in the administrative record file cabinets upon completion of monitoring. Per 725 KAR 1:061 records must be kept according to the DEP record retention schedule approved and updated by the State Archives and Records Commission. Data collected from meters are read from the field sheets and entered into the departmental databases (i.e. KWADE). Data collected from continuous water quality deployments are stored on a DEP server in a project folder.

5. Maintenance, Quality Control and Quality Assurance Section

Calibration verification

Calibration verification shall occur when there are concerns over the results provided by the meter. Verification may also be required during permitting compliance monitoring or TMDL monitoring.

At times, even properly calibrated meters can provide unexpected results for one or more parameters that can be due to, for example, environmental conditions or a meter malfunction. When this occurs it is important to verify that the meter is working properly. Ideally, verification should occur in the field after obtaining the questionable result. At minimum, it should occur after returning from the field by checking the functioning of the meter. The verification must be noted in the meter calibration log and the field datasheet if field verification is performed. Verification is performed using a known standard. A confidence solution can be used when verification is needed for pH or conductivity.

To verify pH, first rinse the probe with pH buffer solution and then place it in an aliquot of the pH buffer solution. pH verification is considered acceptable if pH readings are ±0.2 pH units of the standard.

Verify specific conductance by first rinsing the probe with the standard solution and then placing the probe in an aliquot of the standard. Specific conductance verification is acceptable if the reading is ±2% of the standard.

Verify DO calibration by placing the sensor in its calibration environment (per manufacturer's instructions) and check to see that the instrument is reading the calibration value (100% water-saturated air or air-saturated water) for the current barometric pressure. For example, if the 'true' barometric pressure is 750, divide this number by 760 (barometric pressure with 100% oxygen saturation) and then multiple by 100% to calculate what your instrument should be reading in water-saturated air or air-saturated water. 750/760 x 100 = 98%. DO calibration verification should read ± 2% ≤ 20 mg/L or ± 6% > 20 mg/L once stable.

Verify turbidity by referring to manufacturer's recommendations on verification/calibration.

Storage of sensors

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid. Immersing them could cause some of them to drift or result in a shorter lifetime.

YSI recommends that short term storage (<4 weeks) of all multi-parameter instruments be done by placing approximately 1/2 inch of tap water in the transport/calibration cup that was supplied with the instrument, and by placing the probe module with all of the sensors installed into the cup. DI water should never be used for probe storage as it will shorten the life of pH probes. The use of a moist sponge instead of a 1/2 inch of tap water is also acceptable, as long as its presence does not compromise the attachment of the cup to the probe module. The transport/calibration cup should be sealed to prevent evaporation.

For long term storage (>4 weeks) the unit should be cleaned and batteries removed from any handheld. All pH sensors should be removed from the bulkhead and replaced by a port plug, then stored in the probe shipping bottle with fresh pH 4 buffer. The remaining probes should be stored with clean water in the calibration cup. For additional long term storage methods, including any specialty probes, please refer to the manufacturer's recommendations in the appropriate manual (Appendix A) or other resources.

Replacement of sensors

Sensors must be replaced when calibration results are outside acceptable ranges, and are not brought back within acceptable ranges using manufacturer's maintenance recommendations.

Maintenance

All sensors should be maintained according to manufacturer's recommendations.

In general, an annual inspection and tune up by a qualified individual should be conducted. Any time a probe is removed, the associated o-rings should be examined for cracks or debris and replaced as required. All probes should be cleaned after each use prior to storage.

pH Sensors

All pH probes a slope outside of 95 to 105 percent range should be cleaned and reconditioned following manufacturer's recommendations. If a pH probe still reports out of range, it should be replaced. The typical serviceable lifespan of pH probes used by KDOW are 12-18 months per the manufacturer.

Thermometer

Verification of the meter's internal temperature sensor against a National Institute of Standards and Technology (NIST) traceable thermometer should be performed annually. Any difference between the thermistor and the NIST-traceable thermometer should be noted in the logbook. If the temperatures do not agree within ± 1°C, the probe must be repaired or replaced.

DO

Clark cell DO sensors should have membranes replaced every 30 days or when damaged. Optical sensors should follow manufacturer's recommendations for maintenance and replacement.

Batteries

If meters are not operating correctly, first change or, if rechargeable, charge the batteries in the unit. Low voltages may cause meters to function improperly.

Additional QC procedures

Additional project specific QC procedures that are required to demonstrate successful performance of the method and actions required should be addressed in QAPPs.

6. Reference Section

U.S. Environmental Protection Agency (EPA). 2007. *In situ* Water Quality Monitoring Operating Procedure. United States Department of the Interior, Science and Ecosystem Support Division, Ecological Assessment Branch, Region 4. Atlanta, GA.

7. Appendices

Appendix A – Equipment and User Manuals

Equipment	User Manual
YSI EXO 1 Sonde	EXO User Manual - Advanced Water Quality Monitoring Platform
YSI EXO 2 Sonde	
YSI 556 Multi Probe System	YSI 556 MPS Operations Manual
YSI Professional Plus (Pro Plus) Instrument	YSI Professional Plus User Manual
YSI Professional Digital Sampling System (ProDSS)	YSI ProDSS User Manual

Appendix B – Example Sample Calibration Log Sheet

Manufacturer:																																				
Model:																																				
Serial No.:				Specific Conductance µs/cm					pH															Dissolved Oxygen mg/L												
DOW Inventory #:																																				
Assigned To:																																				
										Initial				Calibrated			pH mV								Initial		Calibrated								
Analyst	Date	Time	Calibration Verification	Standard Used	Temp	Initial SC	Calibrated SC	SC QA	Temp	pH4	pH7	pH10	pH4	pH7	pH10	pH4	pH7	pH10	pH 7-10 Slope (95-105%)	pH 4-7 Slope (95-105%)	pH 7-10 QA	pH 4-7 QA	Barom. Pressure mmHg	Temp	DO	%DO	DO	%DO	Theoretical DO	DO QA	Batteries Changed	DO Membrane Changed	Date DO Membrane Must Be Changed Next		

Appendix C – Barometric Pressure Correction
Frankfort, KY Airport and 500ft Elevation (in. to mm Hg).
True BP = (Corrected BP*25.4) – [2.5 * (Local Altitude/100)].

BP	BP500	BP	BP500	BP	BP500	BP	BP500	BP	BP500	BP	BP500
28.90	721.6	29.48	736.3	30.06	751.0	30.64	765.8	31.22	780.5	31.80	795.2
28.91	721.8	29.49	736.5	30.07	751.3	30.65	766.0	31.23	780.7	31.81	795.5
28.92	722.1	29.50	736.8	30.08	751.5	30.66	766.3	31.24	781.0	31.82	795.7
28.93	722.3	29.51	737.1	30.09	751.8	30.67	766.5	31.25	781.3	31.83	796.0
28.94	722.6	29.52	737.3	30.10	752.0	30.68	766.8	31.26	781.5	31.84	796.2
28.95	722.8	29.53	737.6	30.11	752.3	30.69	767.0	31.27	781.8	31.85	796.5
28.96	723.1	29.54	737.8	30.12	752.5	30.70	767.3	31.28	782.0	31.86	796.7
28.97	723.3	29.55	738.1	30.13	752.8	30.71	767.5	31.29	782.3	31.87	797.0
28.98	723.6	29.56	738.3	30.14	753.1	30.72	767.8	31.30	782.5	31.88	797.3
28.99	723.8	29.57	738.6	30.15	753.3	30.73	768.0	31.31	782.8	31.89	797.5
29.00	724.1	29.58	738.8	30.16	753.6	30.74	768.3	31.32	783.0	31.90	797.8
29.01	724.4	29.59	739.1	30.17	753.8	30.75	768.6	31.33	783.3	31.91	798.0
29.02	724.6	29.60	739.3	30.18	754.1	30.76	768.8	31.34	783.5	31.92	798.3
29.03	724.9	29.61	739.6	30.19	754.3	30.77	769.1	31.35	783.8	31.93	798.5
29.04	725.1	29.62	739.8	30.20	754.6	30.78	769.3	31.36	784.0	31.94	798.8
29.05	725.4	29.63	740.1	30.21	754.8	30.79	769.6	31.37	784.3	31.95	799.0
29.06	725.6	29.64	740.4	30.22	755.1	30.80	769.8	31.38	784.6	31.96	799.3
29.07	725.9	29.65	740.6	30.23	755.3	30.81	770.1	31.39	784.8	31.97	799.5
29.08	726.1	29.66	740.9	30.24	755.6	30.82	770.3	31.40	785.1	31.98	799.8
29.09	726.4	29.67	741.1	30.25	755.9	30.83	770.6	31.41	785.3	31.99	800.0
29.10	726.6	29.68	741.4	30.26	756.1	30.84	770.8	31.42	785.6	32.00	800.3
29.11	726.9	29.69	741.6	30.27	756.4	30.85	771.1	31.43	785.8	32.01	800.6
29.12	727.1	29.70	741.9	30.28	756.6	30.86	771.3	31.44	786.1	32.02	800.8
29.13	727.4	29.71	742.1	30.29	756.9	30.87	771.6	31.45	786.3	32.03	801.1
29.14	727.7	29.72	742.4	30.30	757.1	30.88	771.9	31.46	786.6	32.04	801.3
29.15	727.9	29.73	742.6	30.31	757.4	30.89	772.1	31.47	786.8	32.05	801.6
29.16	728.2	29.74	742.9	30.32	757.6	30.90	772.4	31.48	787.1	32.06	801.8
29.17	728.4	29.75	743.2	30.33	757.9	30.91	772.6	31.49	787.3	32.07	802.1
29.18	728.7	29.76	743.4	30.34	758.1	30.92	772.9	31.50	787.6	32.08	802.3
29.19	728.9	29.77	743.7	30.35	758.4	30.93	773.1	31.51	787.9	32.09	802.6
29.20	729.2	29.78	743.9	30.36	758.6	30.94	773.4	31.52	788.1	32.10	802.8
29.21	729.4	29.79	744.2	30.37	758.9	30.95	773.6	31.53	788.4	32.11	803.1
29.22	729.7	29.80	744.4	30.38	759.2	30.96	773.9	31.54	788.6	32.12	803.3
29.23	729.9	29.81	744.7	30.39	759.4	30.97	774.1	31.55	788.9	32.13	803.6
29.24	730.2	29.82	744.9	30.40	759.7	30.98	774.4	31.56	789.1	32.14	803.9
29.25	730.5	29.83	745.2	30.41	759.9	30.99	774.6	31.57	789.4	32.15	804.1
29.26	730.7	29.84	745.4	30.42	760.2	31.00	774.9	31.58	789.6	32.16	804.4
29.27	731.0	29.85	745.7	30.43	760.4	31.01	775.2	31.59	789.9	32.17	804.6
29.28	731.2	29.86	745.9	30.44	760.7	31.02	775.4	31.60	790.1	32.18	804.9
29.29	731.5	29.87	746.2	30.45	760.9	31.03	775.7	31.61	790.4	32.19	805.1
29.30	731.7	29.88	746.5	30.46	761.2	31.04	775.9	31.62	790.6	32.20	805.4
29.31	732.0	29.89	746.7	30.47	761.4	31.05	776.2	31.63	790.9	32.21	805.6
29.32	732.2	29.90	747.0	30.48	761.7	31.06	776.4	31.64	791.2	32.22	805.9
29.33	732.5	29.91	747.2	30.49	761.9	31.07	776.7	31.65	791.4	32.23	806.1
29.34	732.7	29.92	747.5	30.50	762.2	31.08	776.9	31.66	791.7	32.24	806.4
29.35	733.0	29.93	747.7	30.51	762.5	31.09	777.2	31.67	791.9	32.25	806.7
29.36	733.2	29.94	748.0	30.52	762.7	31.10	777.4	31.68	792.2	32.26	806.9
29.37	733.5	29.95	748.2	30.53	763.0	31.11	777.7	31.69	792.4	32.27	807.2
29.38	733.8	29.96	748.5	30.54	763.2	31.12	777.9	31.70	792.7	32.28	807.4
29.39	734.0	29.97	748.7	30.55	763.5	31.13	778.2	31.71	792.9	32.29	807.7
29.40	734.3	29.98	749.0	30.56	763.7	31.14	778.5	31.72	793.2	32.30	807.9
29.41	734.5	29.99	749.2	30.57	764.0	31.15	778.7	31.73	793.4	32.31	808.2
29.42	734.8	30.00	749.5	30.58	764.2	31.16	779.0	31.74	793.7	32.32	808.4
29.43	735.0	30.01	749.8	30.59	764.5	31.17	779.2	31.75	794.0	32.33	808.7
29.44	735.3	30.02	750.0	30.60	764.7	31.18	779.5	31.76	794.2	32.34	808.9
29.45	735.5	30.03	750.3	30.61	765.0	31.19	779.7	31.77	794.5	32.35	809.2
29.46	735.8	30.04	750.5	30.62	765.2	31.20	780.0	31.78	794.7	32.36	809.4
29.47	736.0	30.05	750.8	30.63	765.5	31.21	780.2	31.79	795.0	32.37	809.7