

SOP-21
Pressure Transducer Water Level Monitoring

Yerington Mine Site
Standard Operating Procedure

Revision 1
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PRESSURE TRANSDUCER WATER LEVEL MONITORING

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1.0 OBJECTIVE

The purpose of this Standard Operating Procedure (SOP) is to promote consistency and quality in the performance of long-term water level monitoring in the vicinity of the Yerington Mine Site located near Yerington, NV. At select locations (that are specified in work plans specific to the various operable units at the Site), high-frequency head measurements are required to better evaluate potential temporal variability in groundwater flow patterns, flow directions (horizontal and vertical), hydraulic gradients, and surface water-groundwater interactions.

Pressure transducers and electronic logging equipment are used to measure and record the head data.

2.0 SCOPE AND APPLICABILITY

This SOP describes the general approach to the performance of long-term, high-frequency water level monitoring to be used in the vicinity of the Yerington Mine Site. The procedure applies to all Brown and Caldwell and contracted personnel authorized to operate or maintain the water level data loggers, or assist with these tasks.

3.0 RESPONSIBILITIES

The *Project manager* is responsible for ensuring the long-term water level monitoring program is implemented in accordance with this SOP and any other site-specific or project specific planning documents.

The *Field Personnel* are responsible for understanding and implementing this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms and records necessary to complete the field activities.

The *Site Safety Officer*, typically the supervising field manager, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field.

4.0 DEFINITIONS

Absolute Pressure: the total or absolute pressure measured by a sensor without correction for atmospheric pressure. A measured pressure that includes atmospheric pressure is an absolute pressure. Units are expressed in pounds per square inch absolute (psia).

Absolute Pressure Transducer: A non-vented or “absolute” pressure sensor measures all pressure forces exerted on the strain gauge, including atmospheric pressure.

Barometric Pressure Transducer: a pressure transducer designed to specifically measure the absolute barometric pressure.

Barometric Pressure Head: Atmospheric pressure that exerts an increased load on the surface of the water column in a monitoring well. This creates an abnormally low water level (depth to water) within the monitoring well.

Bucket Test: a field calibration test intended to determine if a transducer is responding to changes in water levels and operating within factory calibrated standards. The test can be performed in a variety of ways (i.e., in a well, in a 5-gallon bucket, or in a clear tube) using the same basic theory. Obtain a real-time PSI and depth value. Then move the transducer a known distance or submerge in a known amount of water and obtain second real-time PSI and depth value. The difference of the two real-times values should correlate directly with the distance the transducer was moved or the depth to which the transducer was submerged.

Carabiner: an oblong metal ring with a spring clip; used in mountaineering to attach a rope to a piton or to connect two ropes. A carabiner is capable of holding a large amount of weight for a long period of time without becoming distorted or losing structural integrity.

Kellems Grip® and Twist-Lock Connections: the Kellems Grip® is used to attach the data cable to a hanging point inside the well. The twist-lock connection is used to for attaching the transducer and Rugged Reader to the data cable. Both the Kellems Grip and twist-lock connections are shown below.



Manual Water Level: a water level that is taken by hand with a water level meter; usually measured to the hundredth of a foot and reported in feet below measuring point (ft bmp).

Measuring Point: The location on the well from which the hand/manual water levels should be taken. The measuring point will be designated by a white line marked on the black dedicated bladder pump well cap. If the well does not have a dedicated bladder pump the measuring point will be designated by a black mark on the PVC.

Raw Data Files: Electronic pressure transducer data files that are obtained from pressure transducers or data loggers at a well site. Raw data files are usually binary computer files that can be opened, read, and interpreted only by software developed by the transducer

manufacturer. The raw data files must be stored and archived appropriately in order to protect the original data from the pressure transducer. Raw data files contain the raw pressure measurements and date/time stamp from the transducer and may also contain information entered into the transducer software program at the time of installation, such as well name, date/time, measurement interval, reference after elevation at the time of installation, etc.

Real-time Data: data that are reported and/or can be viewed as it is being collected by a data logger.

Rugged Reader: an ultra-rugged, multi-purpose, hand-held PC used to collect, store, and transfer data. Rugged Readers are a product of In-Situ.

Three Stage Decontamination System: the reduction or removal of chemical agents through use of a three separate one-gallon containers:

- One-gallon deionized water with Liquinox
- One-gallon deionized water for rinse
- One-gallon deionized water for sterilization secondary rinse

Strain Gauge: The part of a pressure transducer that senses changes in pressure. It measures the force (expressed as the force per square unit of surface area) that is exerted by water or other fluid on an internal media-isolated strain gauge. Common measurement units are pounds per square inch (PSI) or Newton's per square meter (pascals).

Water Level: 1) depth to water (DTW) in a well below ground surface or measuring point expressed in feet and measured to the hundredth of a foot or 2) the water elevation expressed in feet above mean sea level (ft amsl).

Waterhammer Effect: a pressure surge or wave caused by the kinetic energy of a fluid in motion when it is forced to stop or change direction suddenly.

5.0 REQUIRED MATERIALS

Equipment required for installation, data retrieval, and equipment performance / calibration checks of pressure transducers in monitoring wells.

- LevelTroll 300, 100 PSI Transducers
- Transducer Data Cables
- Manufacturer Operating Manuals
- Rugged Reader

- Field Book
- Field Binder, including:
 - Transducer Performance Check and Maintenance Forms
 - Well Construction Diagrams, and
 - Water Level History of Well
- Water Level Meter, at least 200 feet in length.
- Waterproof ink pens
- Large clear tube with measuring tape attached to side (a 5-gallon bucket may work alternatively)
- Three-Stage Decontamination Station
- Paper Towels
- Trash Bags
- Keys to wells and access gates where necessary
- Nitrile Gloves
- Duct tape
- Measuring Tape.

6.0 LONG-TERM WATER LEVEL MONITORING PROCEDURES USING ABSOLUTE PRESSURE TRANSDUCERS

6.1 Equipment

The long term water level monitoring project in Yerington consists of a network of data loggers installed at various depths in designated monitoring wells. The data loggers are In-Situ Level TROLL 300 absolute (non-vented) pressure transducers rated at 100 PSI. In addition, a BaroTroll is being utilized to collect hourly barometric pressure readings. The reading will be used for calculations which compensate for changes in the water level due to barometric fluctuations. Barometric pressure fluctuations can produce errors on the order of 3 to 8 cm (i.e., 0.10 to 0.26 feet) from day to day, or up to 10 cm (i.e., 0.33 ft) or more as strong weather systems move in and out of an area. The BaroTroll is capable of covering four square miles of area for applicable pressure corrections and thus has been installed at a centralized well. Further, both the BaroTroll and Level Troll 300s have an accuracy of $\pm 0.1\%$ of the sensor's full scale (i.e., the LevelTroll 300s have a full scale of 0 – 100 PSI and therefore an accuracy of 0.1 PSI; the BaroTroll has a full scale of 0 – 16.5 PSI and therefore an accuracy of 0.02 PSI).

Note: When correcting or comparing data from absolute pressure instruments it is critical that one uses the true air pressure and NOT values that have been corrected for altitude; i.e. a broadcast weather report usually reports corrected barometric pressure reading that have been compensated for elevation.

The pressure transducers are installed in a well via rugged twist-lock data cables. Having data cables attached to the transducers will eliminate measurement error associated with the removal and reinstallation of transducers (i.e., the transducer being reinstalled at an incorrect depth or tangling and knotting of the cable causing a change in length of the cable). The lengths of the data cable at an individual well should be based on historical water level data that represents the full range of expected water level fluctuation.

To download the data from the pressure transducers a hand held field PC 'Rugged Reader' is used. The Rugged Reader is capable of connecting directly to the data cables for data collection. Further, the Rugged Reader can then be connected to a PC to download field data for data reduction and analysis. Alternatively, a Windows based operating system PC laptop with the proper version of In-Situ software can be utilized for downloading and programming the pressure transducers.

6.2 Transducer Maintenance

General maintenance of pressure transducers consists of cleaning the body and front end of the transducer. To clean the body use water and a soft brush or plastic scouring pad, or soak overnight in a mild acidic solution, such as household vinegar. In the event that the transducer came into contact with mud or silt which may have clogged the ports in the front end of the transducer try the following: swish the instrument vigorously in a bucket of clean water; apply a gentle squeeze of water from a wash bottle; or, in severe cases, remove the nose cone and clean out the holes with a soft brush or pipe cleaner.

Note: Do not insert any object into the sensor opening or attempt to dig out dirt or other materials. This may damage the pressure sensor diaphragm.

6.3 Transducer Installation

The procedure for installation should only have to be performed once per transducer. However, if a transducer is determined to have come out of calibration or has a low battery life remaining it may need to be removed from the well then replaced or reinstalled.

1. Obtain a barometric pressure reading from the BaroTroll or the air monitoring station web site. Record on the transducer installation form.
2. Locate measuring point on well. The measuring point will be located on the black dedicated pump well cap indicated by a solid white line. Insert the water

level meter through the large hole in the well cap and lower meter to water surface.

3. Collect a manual water level reading measured to a hundredth of a foot using a 200' water level meter from the measuring point on well. The sensitivity setting for the water level meter for the site is typically low, 2 or 3. To ensure accuracy of water level reading, take multiple readings and compare them to historic measurements.

Note: If possible, use the same water level meter for all future readings to eliminate measurement error.

4. On the transducer installation field form, record exact time of reading and the manual water level with units of feet below measuring point.
5. Select a data cable to install the pressure transducer. The cable should be designed so that the transducer will be located at an appropriate depth to monitor the full range of expected water level fluctuations. Record the cable length on field form.
6. Connect the data cable to the transducer at one end and to the Rugged Reader on the other end via twist-lock connections.
7. Check for appropriate communications with transducer by clicking the  button. This will electronically connect the Rugged Reader to the transducer.
8. Synchronize the transducer's date and time with Rugged Reader using Win-Situ 5 software. If necessary, add a new site in the site data section. See Attachment B for procedures.
9. On the transducer installation field form record the transducer's serial number and battery and storage information.

Note: If the transducer has not been calibrated by the manufacturer in the last year, perform a 'bucket test' as described in the Field Calibration Procedures below. If performed, record results on the appropriate field form.

10. Carefully lower the transducer into the well.

Note: Be mindful to not allow the cable to rub against the sharp edges of the casing. Do not allow the transducer to contact the water level at a high rate of speed; this can damage the transducer's strain gauge called the 'waterhammer effect'. Do not submerge transducer to a water depth pressure greater than the pressure rating of the transducer.

11. On the Rugged Reader, take a reading or view real-time data. Check to see if the transducer is at the desired depth; if not, adjust appropriately.
12. Once the desired depth is reached, secure the data cable via the Kellems grip. The grip can be slid along the cable to the desired position by compressing it at both ends and secured by re-stretching the grip. Use the loop of the Kellems

grip to anchor the cable to the well cap; if necessary a karabiner can be used to attach the data cable to the well cap.

13. Now check the level of water (reported as depth) above the transducer again. Move the transducer a known distance and read the depth again to be sure that the probe is giving a reasonable reading and showing change.

Note: it is not uncommon for the water level to rise (especially in wells with low hydraulic conductivity) while the data logger is being inserted.

14. Anchor the transducer and mark the cable with electrical tape at the bottom of the Kellem's grip. Doing this documents cable placement and allows for detection of cable slippage or tampering.
15. Collect periodic manual water levels until the water level has returned to static equilibrium.
16. When subsequent water levels have equilibrated, use the field form to calculate and record the depth of the transducer in the well by adding the manual water level reading to the depth value reported on the Rugged Reader (in 'depth' mode or on the logging setup screen) by the transducer. Do not forget to compensate for barometric pressure by subtracting the BaroTroll's PSI value converted to feet.
17. Allow the transducer to stabilize to the water conditions for an hour.
18. Program transducer to begin logging at the frequency specified in the applicable work plan; log pressure in PSI, temperature in C, and depth in feet. When prompted to choose the specific gravity of the water choose the 'fresh' option. Finally, program the transducer for logging to read in 'depth to water' mode using the depth to water value recorded on the transducer installation form.
19. Take one further manual water level measurement to confirm the real time value reported by the transducer matches with the manual water level measurement.
20. Detach Rugged Reader from data cable, close and lock well monument.

Note: Make sure the well has sufficient venting to allow the well water to be in contact with the atmosphere (i.e., do not seal a locking well cap to the well).

21. Decontaminate water level meter using three stage decontamination system.

Note: To verify that the transducer is functioning correctly, check transducer within 1 week after installation.

6.4 Data Retrieval

Upon arrival to site record date, arrival time, and weather conditions in field book.

First Procedure (Prior to Field, on day of field work):

1. Obtain absolute barometric pressure reading from a certified barometer (not a weather station), or the local Yerington Air Monitoring Station web site and record value in PSI on the field form. The field form is attached as Attachment A. Subtract the current barometric pressure from the barometric pressure at the time of logger programming and convert value to feet. This value represents some of the allotted margin of error, as will be described in step seven of the Second Procedure below.

- Reference calculations: 1 mmHg = 0.019 PSI

1 mbar = 0.0145 PSI

1 ft = 2.31 PSI

Second Procedure (all LevelTroll pressure transducers):

1. Locate the measuring point on well. The measuring point will be located on the black dedicated pump well cap indicated by a solid white line or a black line on the PVC casing. Insert the water level meter through the large hole in the well cap and lower meter to water surface.
2. Collect a manual water level reading, measured to a hundredth of a foot, using a 200' water level meter from the measuring point on the well. The sensitivity setting for the water level meter for the site is typically low, 2 or 3. To ensure accuracy of water level reading, take multiple readings.

Note: If possible, use the same water level meter for all future readings to eliminate measurement error.

3. On the field form record exact time of reading and the manual water level with units of feet below measuring point (fbmp).
4. Attach the Rugged Reader to the data cable and download data from transducer. Record the name of the file on the field form.
5. On the Rugged Reader, view the real-time Depth to Water value and record value on the field form.
6. Compare the manual water level reading to that of the transducer Depth to Water reading.
7. Perform a field calibration check to determine if the transducer is working properly. This is done by ensuring that the manual water level reading and the transducer's Depth to Water level readings are ideally within 0.3 feet of each other. However, the logger may be off by an additional amount as calculated from the difference in barometric pressure from the time of instrument programming (step one of the First Procedure).

Note: Data will be removed from the transducer annually at the end of January.

8. Decontaminate water level meter using three stage decontamination system.

Third Procedure (BaroTroll transducer only):

1. Proceed to B/W-2D, attach BaroTroll to the Rugged Reader via twist lock connection and download BaroTroll data. Attachment B describes the procedure for downloading data.
2. Refer to the absolute barometric pressure reading from a certified barometer (not a weather station), or the local Yerington Air Monitoring Station web site as recorded on the field form.
3. Record BaroTroll PSI reading on the field form and compare to ambient barometric pressure reading from Step 2 above. To determine if the BaroTroll is performing properly ensure difference in the two readings is less than 0.02 PSI.
4. Download BaroTroll data to Rugged Reader as described in Attachment B. Record the filename on the field form.

6.5 Transducer Performance/Calibration Field Checks

The pressure transducers can come out of calibration for many reasons. The most common include: exposing the pressure sensors to pressures and temperatures beyond their normal operating range, bumps and jolts, lightning and similar surges, as well as normal drift in the device's electronic components. In the event that further field calibration checks are required; i.e. a transducer is installed without a data cable, a 'bucket test' can be performed as a field calibration evaluation. The best method is to have a clear tube filled with water into which the instrument can be placed. By permanently mounting a measuring tape to the outside of the tube, the exact amount of water above the pressure sensor can be manually measured and compared against the instrument's reading. For example, six inches of water above the transducer should return a change in depth of 0.5 feet. Because data cables have been installed for the transducers in Yerington, an initial 'bucket test' can be performed while the transducer is still in the well. Simply take a real-time data reading, move the transducer up in the well a known distance (i.e. three feet), and take a second real-time data point. Observe and verify that the transducer is responding appropriately to changes in depth. One further quick calibration check can be done by observing the transducer's pressure readings in open/absolute air pressure and comparing the reading to that of the BaroTroll.

6.6 Field Calibration Procedures

The field calibration method recommended for non-vented transducers by In-Situ is called a Factory Reset. Perform a factory reset if a transducer fails the performance/calibration field check.

1. Attach the Rugged Reader to the transducer via twist lock on the data cable or transducer.
2. Stop the recording log. **Make sure the data has been extracted from the transducer.**

Note: This procedure erases all data on the transducer and returns it to its factory settings.

3. On data logger, click view and then setup. Next, click the delta and then reset.
4. Return to the transducer Home screen on the data logger and check to see if the real-time PSI reading matches that of the BaroTroll to within 0.25 PSI.

If the transducer does not read an acceptable PSI after performing the Factory Reset, the transducer will need to be sent to the manufacturer for factory recalibration. Before shipping the transducer back to the factory it must be decontaminated. Further, a Decontamination and Cleaning Statement, located in the Level Troll Operator's Manual and as Attachment C, must be filled out and sent with the transducer.

Note: Field recalibration is not available for a BaroTroll.

6.7 Data Reduction

Data Reduction will be performed using the In-Situ software Win-Situ Sync, Win-Situ 5, BaroMerge, and Excel. With the exception of Excel, the programs can be installed on a computer from a CD provided with the transducers or downloaded from the In-Situ web site. The use of these programs allows for the data to be copied from the Rugged Reader to the Carson City server, converts the data to workable files, and further performs barometric pressure compensation calculations.

1. Attach the Rugged Reader to the computer via USB port. If Rugged Reader does not turn itself on, turn on Rugged Reader and the computer will auto-detect and additionally auto-download the raw data files using the Win-Situ Sync program.

Note: The Win-Situ Sync program has an option to delete the data from the Rugged Reader after the download. Check the box to remove data from the Rugged Reader.

2. Open Win-Situ 5 and check to see if the raw .wsl files were successfully transferred from the Rugged Reader.

3. Save each raw .wsl file to the Carson City server in the directory:
 \\bccar01\Projects\ARCO\132025 – Second Step Hydrogeological Investigation\General\Transducer Data\Transducer Data Files.
4. Next, click Tools. Then click Win-Situ BaroMerge. This will prompt the BaroMerge program.

Note: The BaroMerge program is designed to perform the barometric pressure compensation calculation. If a pressure transducer was not installed properly; i.e. to take data readings at the same time as the BaroTroll, the BaroMerge program will interpolate between the two barometric pressure data points to accommodate for the time difference.
5. In the BaroMerge program, browse for and select the appropriate BaroTroll file. The file is generally the last retrieved data file.
6. Next, select the site data files which need to be corrected for barometric pressure. When finished, click the large check mark and BaroMerge will perform the barometric pressure compensation calculations and close. New files with *filename*-BaroMerge.wsl will appear for each corrected file in the respective site data folder.
7. Export the barometric pressure corrected data files to .csv files by right clicking each file and selecting 'Export to CSV'.
8. For each .csv file: open the file with Excel. Copy the contents of the 'Date and Time' column, the 'Depth to Water' column, as well as the 'Pressure (PSI)' column for the 100A (or the transducer's serial number) Sensor into the appropriate well tab and column located in the Transducer Data and Hydrograph.xls file.
9. In Excel, enter the manual water level readings into the appropriate location on the spreadsheet. If new monthly water level values are available enter them into the spreadsheet as well. Next, convert the Depth to Water column to elevation values. Finally, add all new depth data to the existing hydrographs.

- Reference Calculation: 1 PSI = 2.31 feet

6.8 Data Management

The raw .wsl data files will be uploaded and archived in the project database. In addition, the files will be available for data evaluation and reduction in the Carson City office.

7.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance activities which apply to the implementation of these procedures are located in the site QAPP, including record keeping such as field notes and field forms. In addition, the following general procedures apply:

- All data must be documented on field data sheets or within site logbooks.

- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan.
- Equipment performance checks will be completed and documented each time a transducer is utilized. If necessary, field calibration procedures will also be implemented and documented.

8.0 REFERENCES

Brown and Caldwell, 2007c, *Second-Step Hydrogeologic Framework Assessment (HFA) Yerington Mine Site, Lyon County, Nevada*. Prepared for the Atlantic Richfield Company.

Brown and Caldwell, Revision 2, 2007, *Draft Quality Assurance Project Plan*. Prepared for Atlantic Richfield Company.

In-Situ Inc, 2007. *Level TROLL Operator's Manual*. http://in-situ.com/In-Situ/Downloads/Downloads_OpManuals.php

In-Situ Inc, 2007. *Blue Rugged Reader Operator's Manual*. http://in-situ.com/In-Situ/Downloads/Downloads_OpManuals.php

Norwest Applied Hydrology, 2007, *Field Sampling Plan for Groundwater Monitoring Wells Yerington Mine Site*. Prepared for Atlantic Richfield Company.

Weight, W. and Sonderegger, J., *Manual of Applied Field Hydrogeology*, McGraw-Hill, 2001

9.0 ATTACHMENTS

Attachment A – Transducer Data Retrieval Field Form

Attachment B – InSitu Downloading Instructions

Attachment C – Decontamination and Cleaning Statement

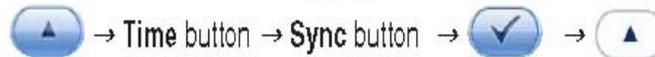
In-Situ instructions for syncing the clocks, adding a new site, and downloading data to the Rugged Reader.

SECTION 6: IN-SITU SOFTWARE

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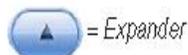
Set the TROLL's Clock

Set the device clock before logging: From Home, tap this sequence:



Add a Data Site

Data logs are organized and filed by the **Site** where the data were collected. The first thing you will be asked for in a log configuration is a site name. If a default site is provided, it may be used. But to clearly identify the place where data were logged, enter a new site, like this:



A File menu > New Site, tap the **New** button

B You are prompted for a Site name. There are 2 keypads you can use to enter text:
 cellphone-type keypad
 standard keypad

C Key in a short identifying name, then tap OK or to close the keypad

D Accept the default update rate, tap next

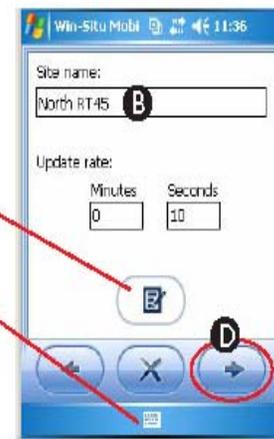
E In the next screen, enter site coordinates if you want, or tap OK to finish

F When the new site is shown again, tap OK

G When the Home tab returns to the screen, tap the site button



, select the new site, tap OK. Your new site is now shown in the Home tab and is ready to use in logs.



Set up a Data Log

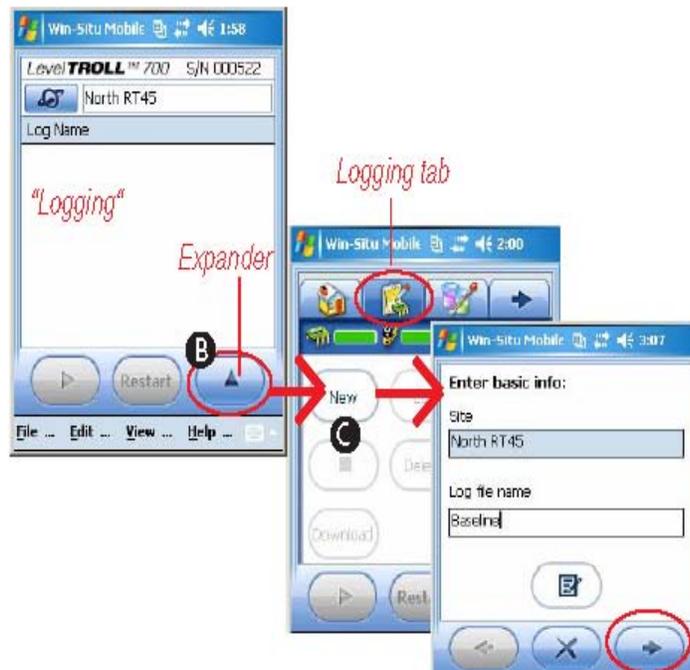
- A** Tap View menu > Logging to go to the Logging tab.
- B** At the Logging tab, tap the Expander button .
- C** In the Expander, tap the **New** button. The logging setup wizard starts. Follow the steps in the wizard, tapping Next  to continue in each screen. For help on the prompts, see the Win-Situ Mobile Quick Start included with your RuggedReader.

 = Expander

 = OK

 = Next

At the end of the Logging Setup Wizard, a summary of the log setup is shown. Tap OK  to write the log to the device.



-  = Manual Start log
-  = Scheduled Start log
-  = Running log

Start the Log

A Scheduled log starts at its programmed time.

To start a Manual log: Tap View menu > Logging, tap the log, tap Start. 

You can safely disconnect from the RuggedReader now.



Start

Download/View the Log

Tap View menu > Logging, tap the log, tap the Expander, tap **Download**. To view the data, select Yes at the end of the download. In My Data tab, tap **View**.

Stop the Log

Tap View menu > Logging, tap the log, tap the Expander, tap Stop 



- A** Tap the log
- B** Tap the Expander
- C** Tap an action button

Exit Win-Situ Mobile

When you're ready to exit Win-Situ Mobile, tap File menu > Exit.

ATTACHMENT C

In-Situ Statement of Decontamination and Cleaning to be completed and filled out prior to returning a transducer for factory recalibration.

Decontamination & Cleaning Statement	
Company Name _____	Phone _____
Address _____	
City _____	State _____ Zip _____
Instrument Type _____	Serial Number _____
Contaminant(s) (if known) _____ _____	
Decontamination procedure(s) used _____ _____	
Cleaning verified by _____	Title _____
Date _____	