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Low-Flow Groundwater Sampling:

Using In-Situ, Inc. Troll 9500 Multi-Parameter Probe & Flow-Sense™ Software.

David A. Wardwell – In-Situ, Inc. Groundwater Market Manager

Overview:

This document provides a description of low-flow sampling techniques, a summary of federal low-flow guidance documents, and outlines the operation of a Troll 9500 using Flow-Sense™ Software.

What is Low-Flow Ground-Water Sampling?

Low-Flow Groundwater sampling is an increasingly accepted method of collecting groundwater samples with a strict set of guidelines to ensure better sample representation and quality. Groundwater is extracted from the well at a very low rate (<500mL/min), and drawdown of the water level is stabilized. Water is pulled from the more hydrogeologically conductive areas of the aquifer around the well screen, and monitored with water quality sensors for stability to determine chemical change from well water to formation water. Once stabilization occurs, a sample can be taken with the greatest assurance of representative formation water, and least amount of geochemical disruption to the sample.

Why Should I Use Low-Flow Ground-Water Sampling Methods, and a Troll 9500?

- It is required in my sampling plan, or scope of work.
- Improve sample quality.
- Improve sample representativeness.
- Reduce wastewater created by large volumes of sample purging.
- Save time in the field with preliminary set-up of sampling events with Flow-Sense™ Software, in a dry office.
- Save time in the field with automated data collection and stabilization of water quality parameters
- Eliminate errors created by manual field recording, and manual data transcription.
- Create more detailed sampling summaries, records, and reports that can be repeated.
- Save time and money with quick and easy digital report formats.
- Look more professional with clean digital sampling reports that can be inserted directly into your project deliverables.
- Provide a complete calibration history of the sampling event to ensure sample validation.
- Create a digital sampling record that can be easily replicated by any field person.
- Save time and money by digitally organizing your sampling events.

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Low-Flow Federal Guidance Summary:

The following is a one page summary of existing federal guidance covering what is necessary or required in order to properly complete a low-flow ground-water sampling event.

Summary:

1. **Low-Flow** – refers to the velocity that is imparted during pumping to the formation pore water adjacent to the well screen, not necessarily the flow rate of water discharged by the pump.
2. **Low-Flow Purging** can be used on any well capable of being pumped at a constant rate of 1.0 L/min or less without continual drawdown of the water level in the well.
3. A typical **flow rate** from a pump during low-flow purging is on the order of 0.1 to 0.5 L/min.
4. **Pumps** – Continuous discharge pumps with variable flow-rates are preferred (Grundfos, Fultz; Nomad, Keck, Proactive). Cyclic discharge is also acceptable (bladder pumps). Dedicated pumps are preferred. Grab sampling devices such as bailers, Kemmerer samplers, and inertial-lift devices cannot be used. Peristaltic pumps are discouraged because of loss of VOCs, degassing, ORP and pH changes.
5. You must have a **water-level indicator** for initial readings and drawdown monitoring with accuracy (±0.01 ft /3 mm).
6. **Flow Cells** are preferred for monitoring, especially for DO and ORP readings, which will be altered if exposed to atmosphere.
7. **Calibration** of multi-parameter equipment is required once a day, with periodic checks.
8. The pump should be placed at the mid-point of the submerged well screen.
9. **Drawdown** in any well should not exceed (0.1m/0.33ft/4in.), or 25% of distance from top of well screen to pump intake.
10. **Stabilization Parameters** – pH ±0.2 pH units, Cond ± 3% of reading, DO ± 10% of reading or 0.2 mg/L whichever is greater, and ORP ±20 mV. Turbidity is not always required, but ± 10% of prior reading or ± 1.0 NTU, whichever is greater
11. **Flow cell sample rates** – The frequency of measurements should be based on the time required to completely evacuate one volume of the flow cell and associated tubing and pump volume.
12. **Stabilization** – is reached when 3 consecutive readings meet the stabilization criterion listed above, when sampled at the established proper rate.
13. **Field Reporting Requirements:**
    a. Equipment Calibration Report
    b. Site Specific Data (project name, Site, Well no., well depth, well diameter, screen length, casing type, pump type, tubing type)
    c. Initial Water Level
    d. Pump Placement/Type (relative to well screen and static water level)
    e. Final pumping rate
    f. Final stabilized draw-down
    g. Water Quality measurements (date, time, temp, pH, ORP, Cond, DO, Turb.)

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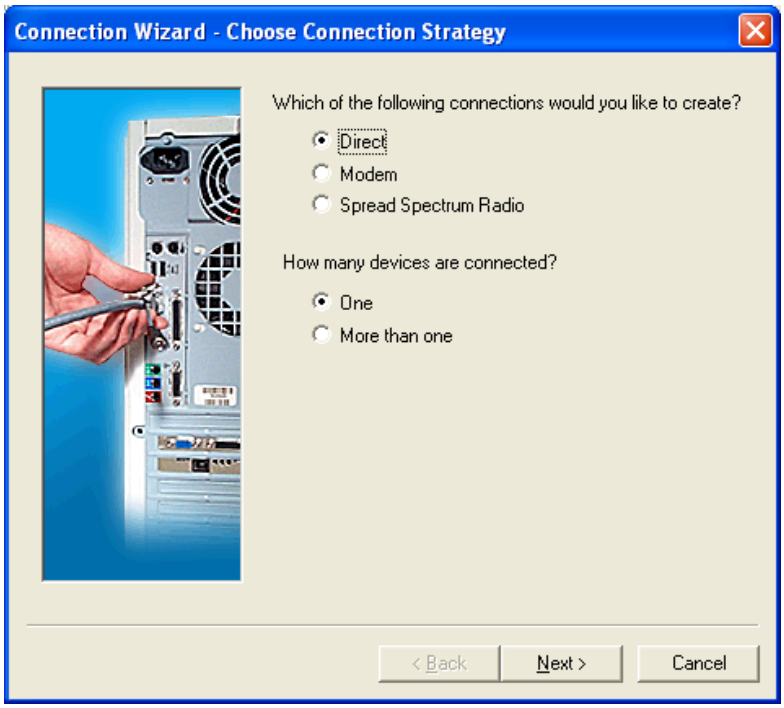
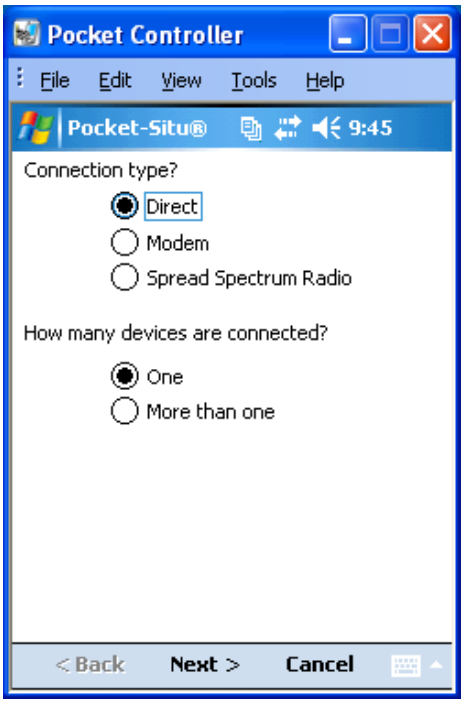
Field Equipment:

- Troll 9500 Low-Flow Sampling System
- Pump and Tubing
- Water Level Indicator
- Graduated Cylinder
- Visqueen and other PPE
- Sample Jars
- Overflow 5-Gallon Buckets

Troll 9500 Equipment Connection/Calibration:

- Connect up to your Troll 9000, and open Win-Situ 4.0. When you first connect, a connection wizard will start, choose **Direct** connection to **One** device





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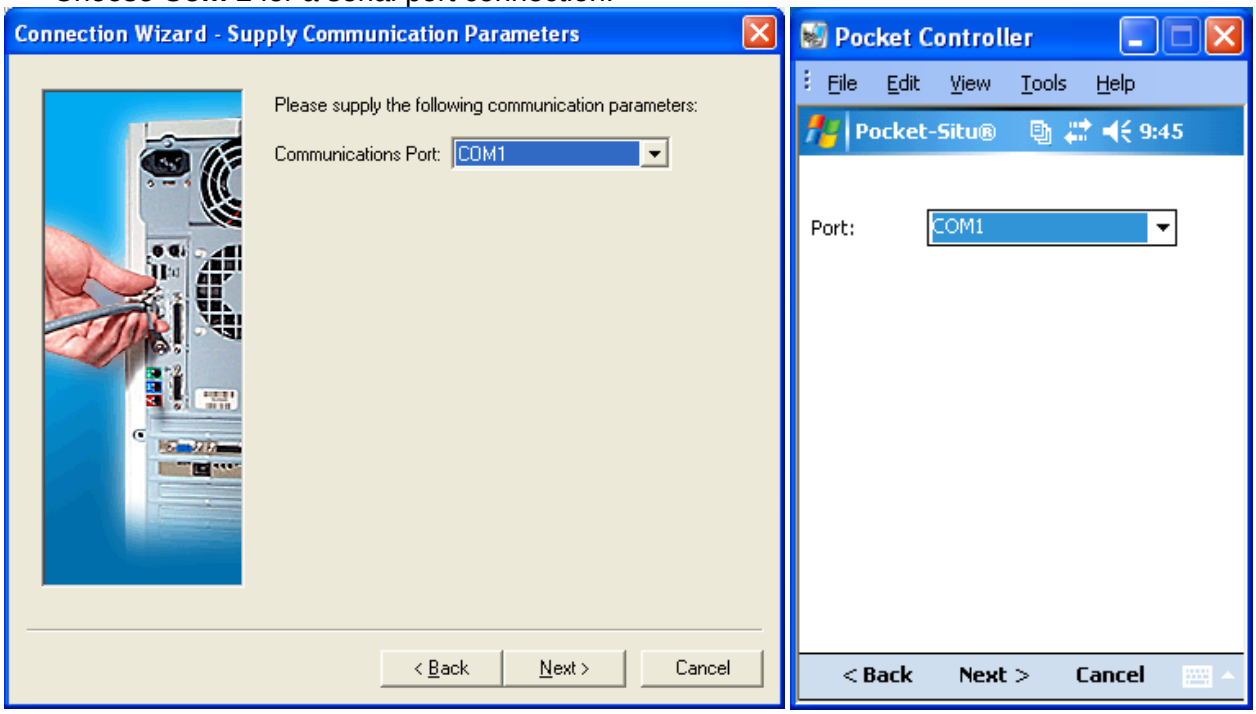
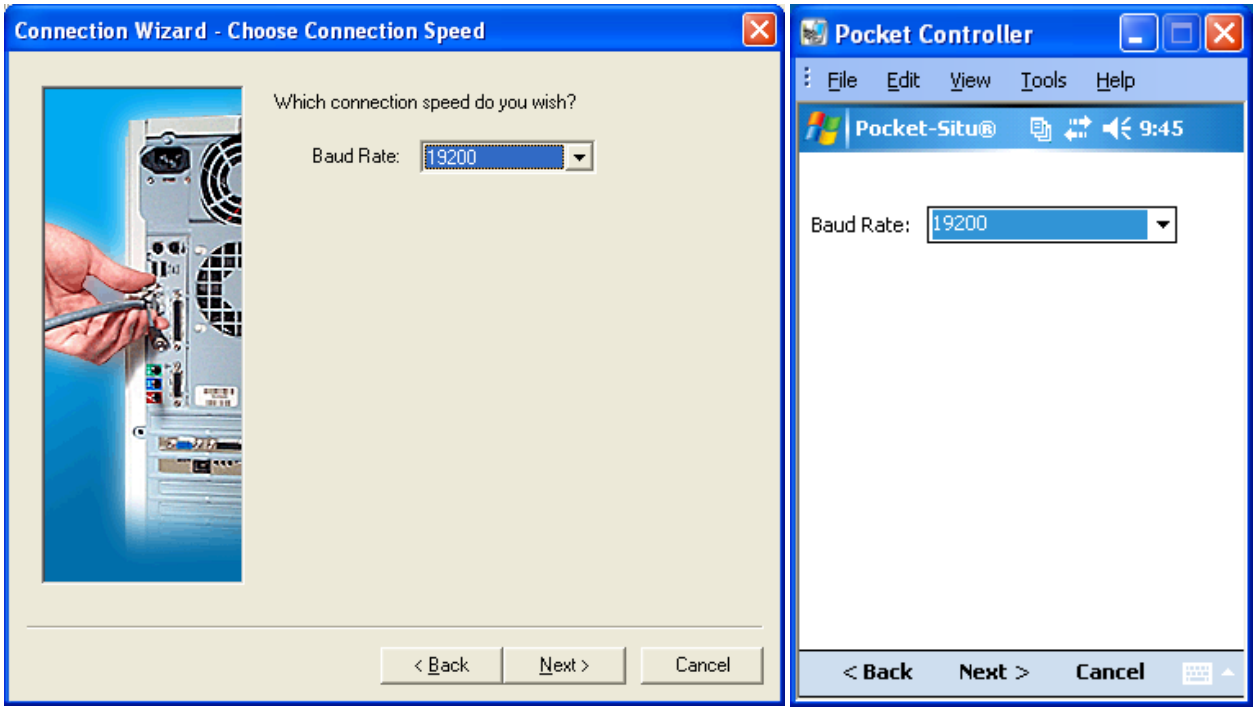
- Choose **Com 1** for a serial port connection.



- Choose a Baud Rate of **19200**



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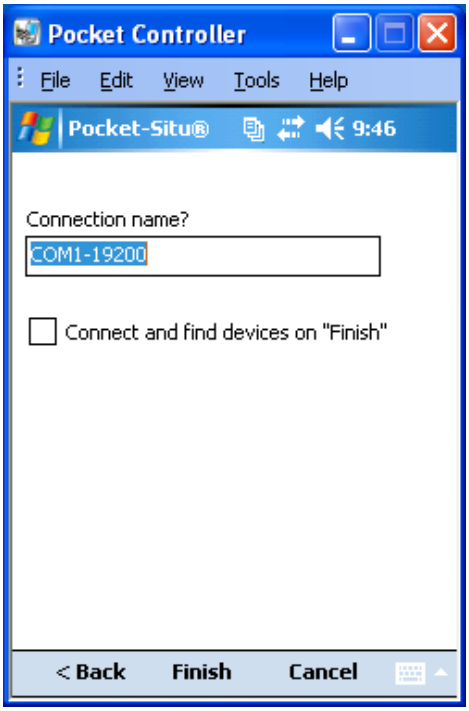
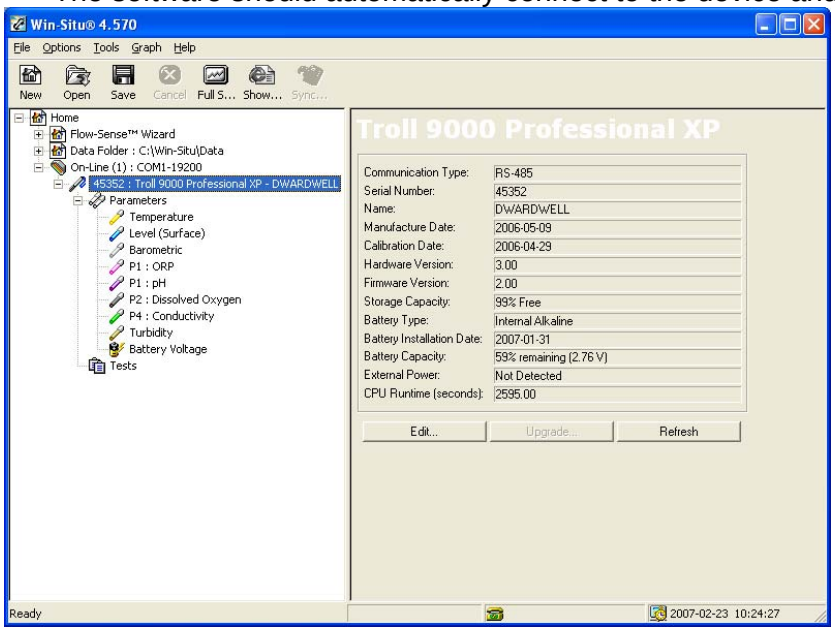
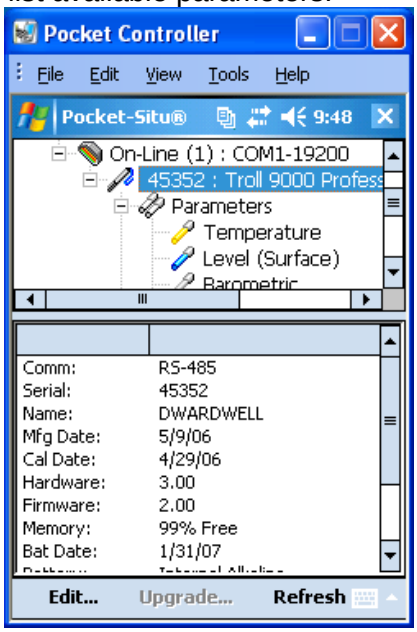
- Choose a name for your connection, the default **COM1-19200** is fine.



- The software should automatically connect to the device and list available parameters.





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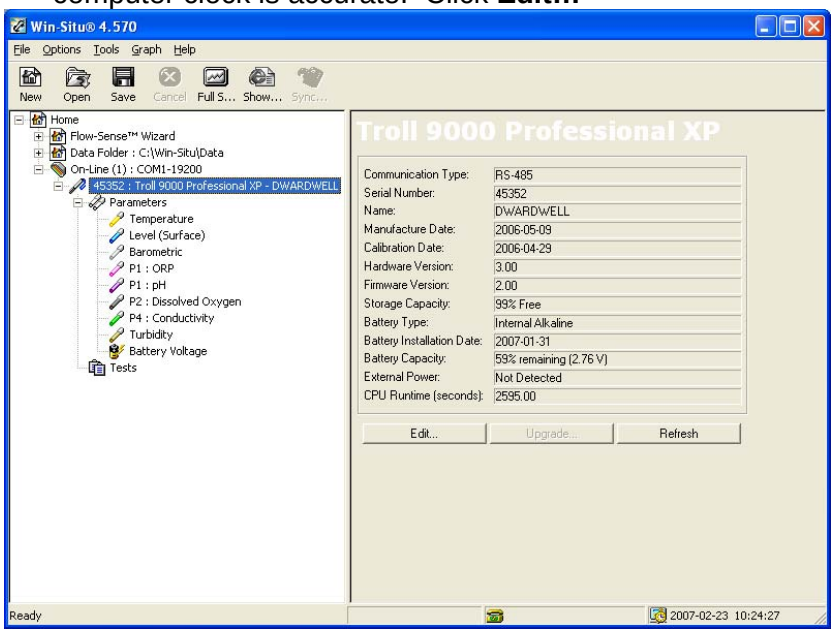
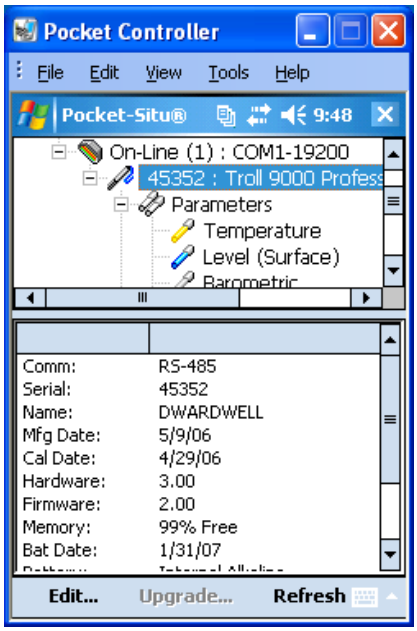
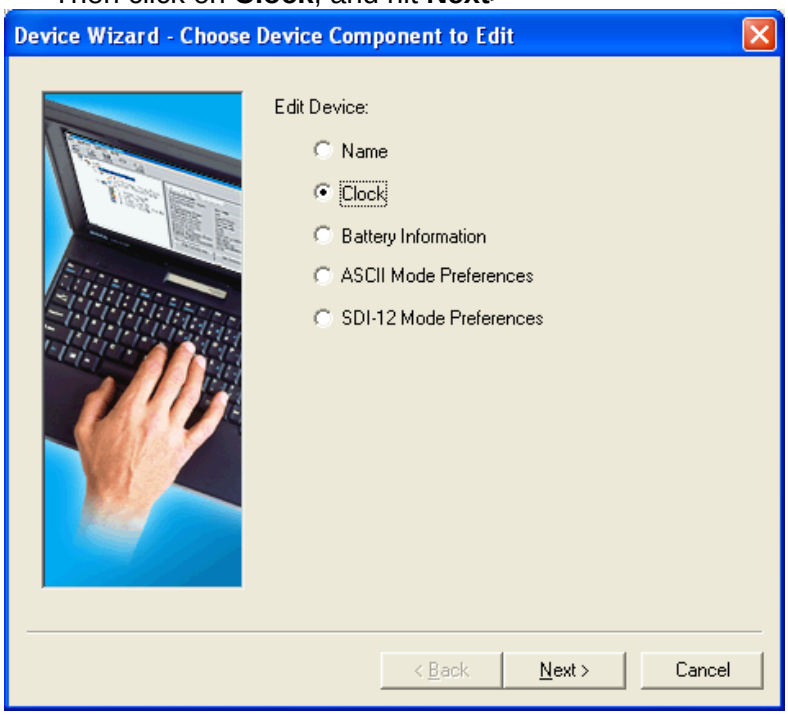
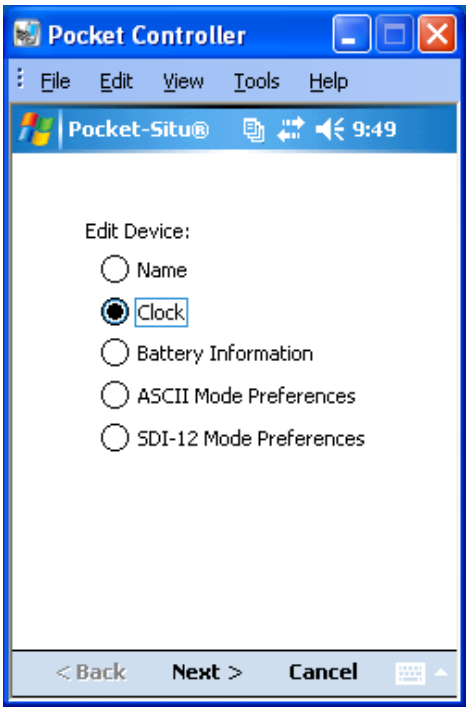
- The first thing to do is check your battery capacity, make sure you have over 50% to work for the day, just to be sure. If you want to change batteries, put in 2 new D cell batteries.
- Next, synchronize the Troll 9500 clock with the clock on your computer. Make sure the computer clock is accurate. Click **Edit…**





- Then click on **Clock**, and hit **Next>**





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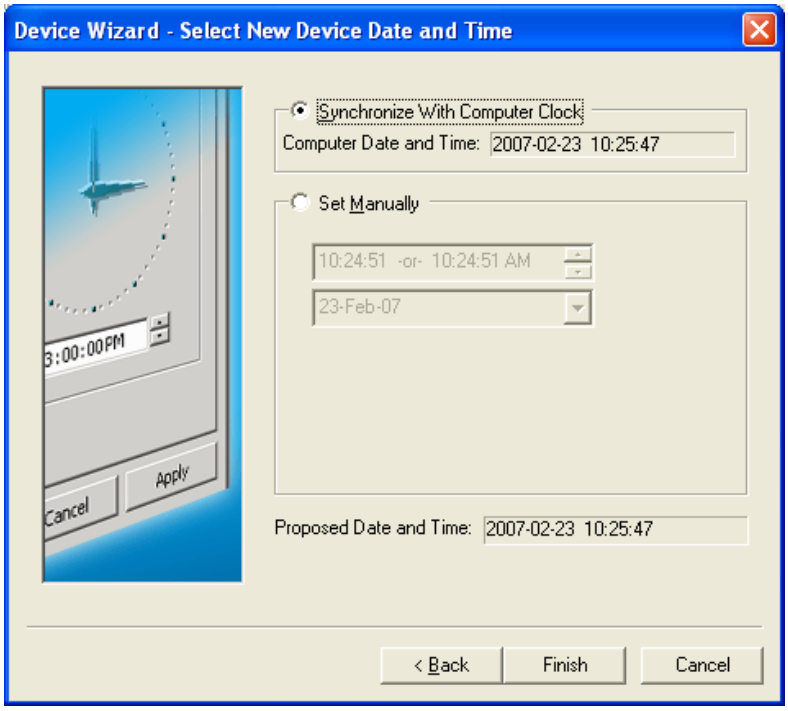
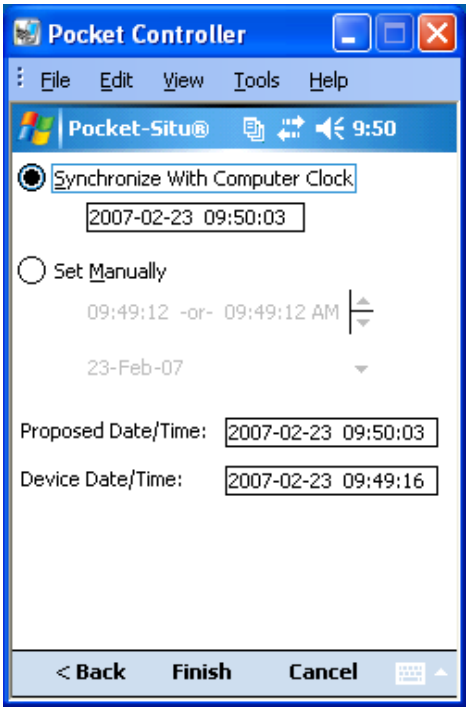
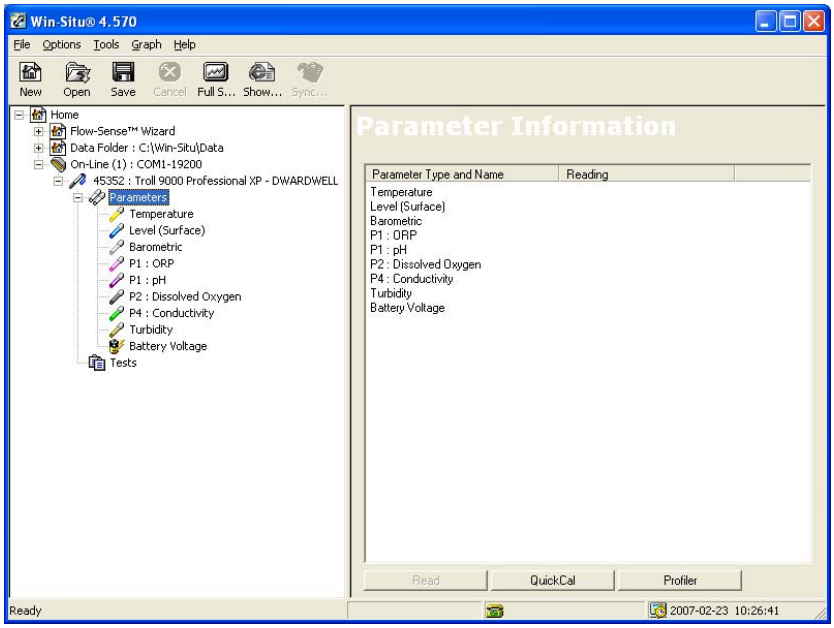
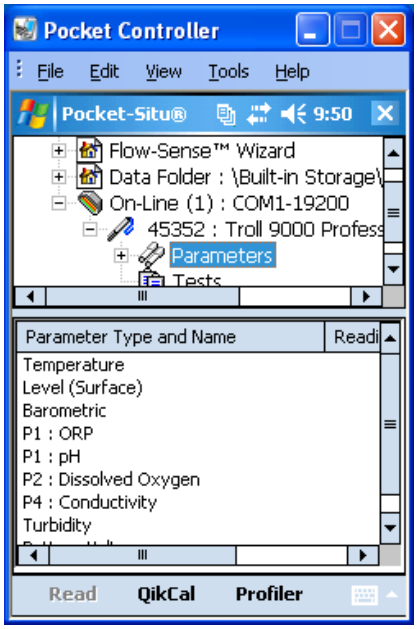
- Click on **Synchronize With Computer Clock**, and click **Finish**.
-





- To Calibrate, highlight **Parameter**s, and click **Quick Cal**.
-





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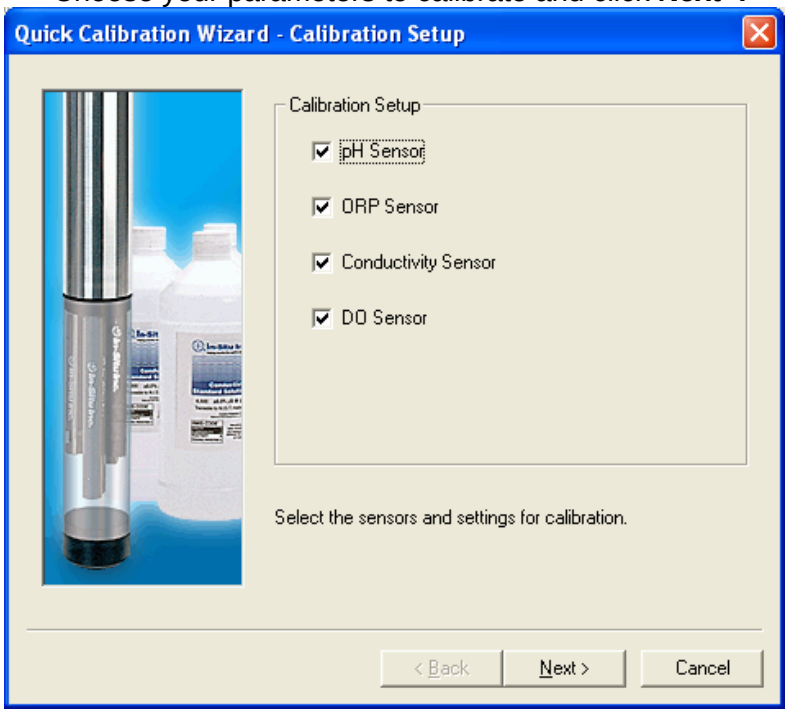
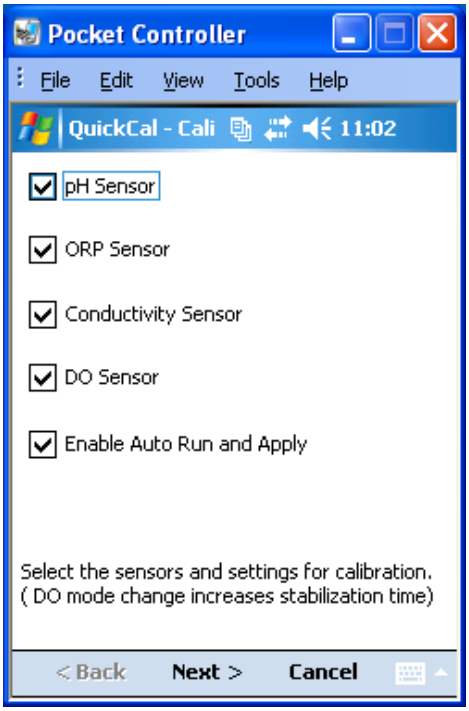
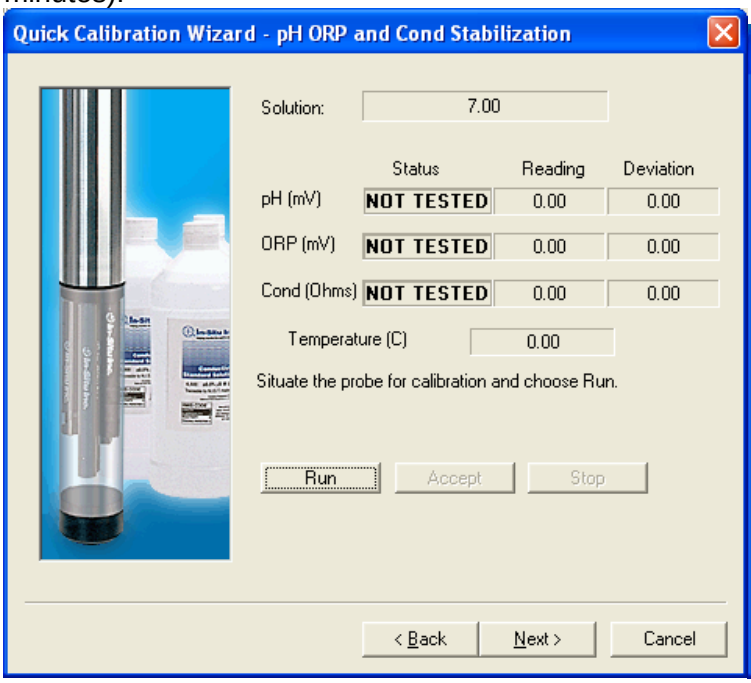
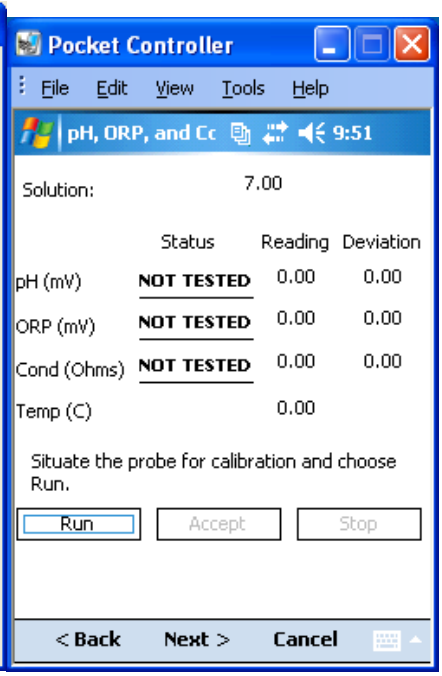
- Choose your parameters to calibrate and click **Next>.**





- Fill the CalCup with ISI Quick Cal Solution, click **Run**, and wait for pH, Conductivity, and DO to automatically stabilize. (May take a few minutes).





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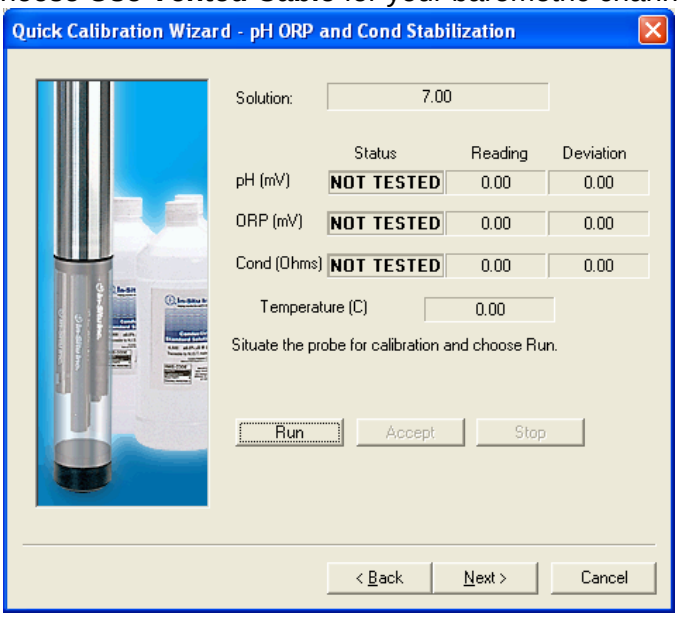
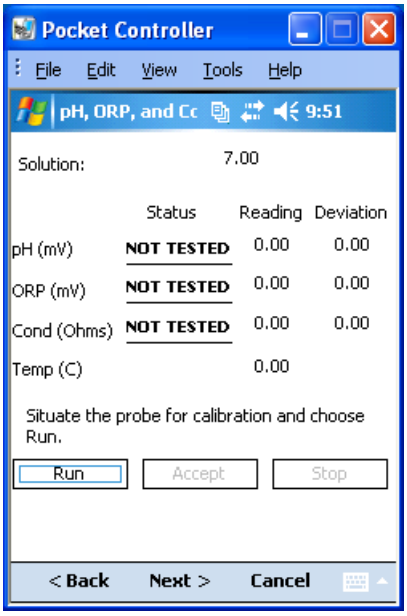
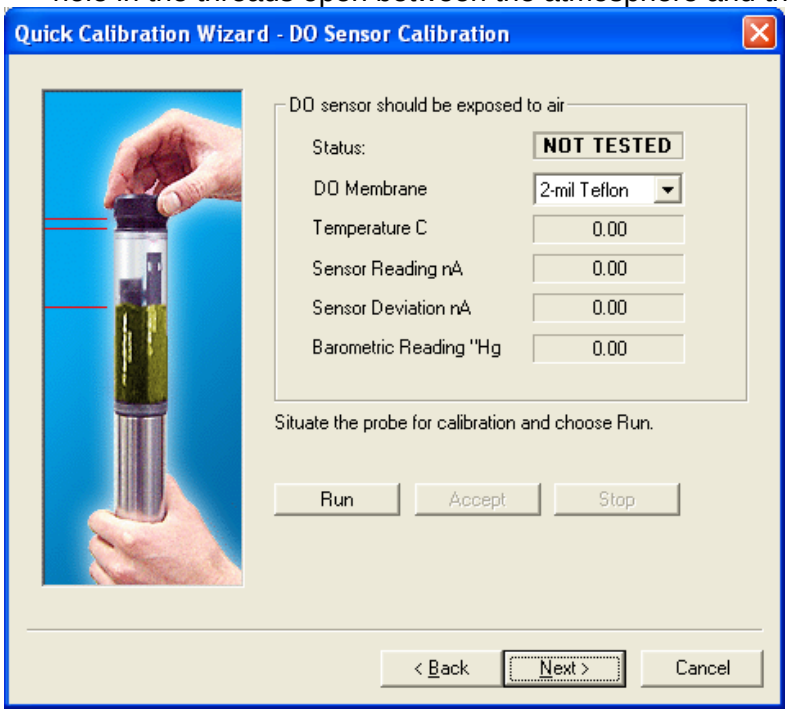
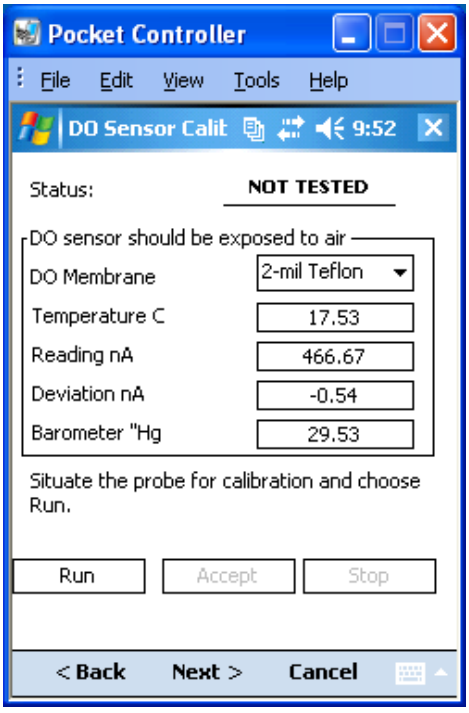
- Choose **Use Vented Cable** for your barometric channel. Click **OK**.





- Take the Troll 9500, and place it with the sensors pointing up. Unscrew the black end cap above the sensors. Empty out adequate Quick Cal solution so expose the DO sensor membrane to the atmosphere. Screw the black cap back onto the cal cup, but leave the hole in the threads open between the atmosphere and the sensors. Click **Run**.





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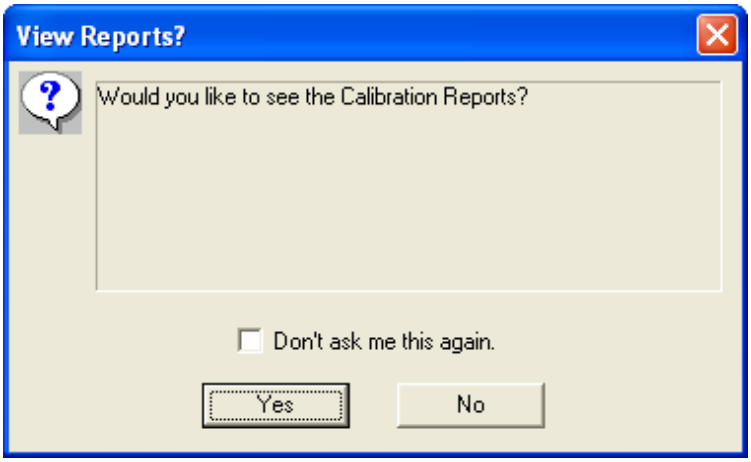
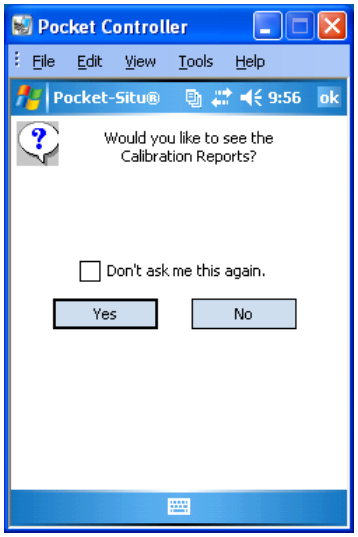
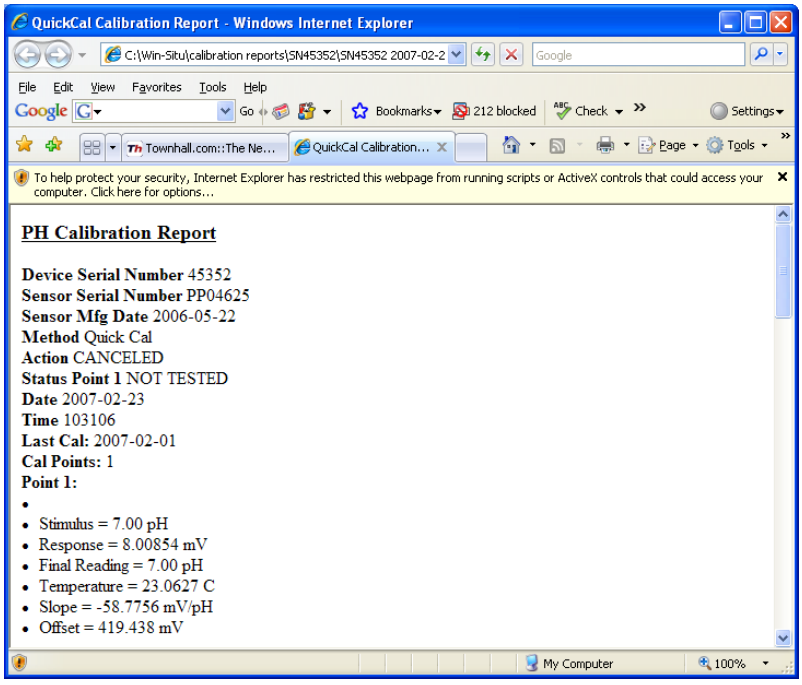
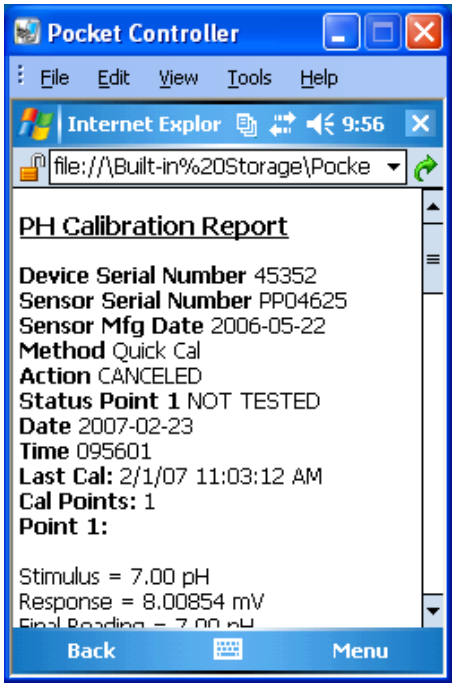
- When the calibration is complete the software will automatically generate digital calibration reports and save them on your hard drive. Click **Yes** to view them.





- The calibration report is generated with the following data.





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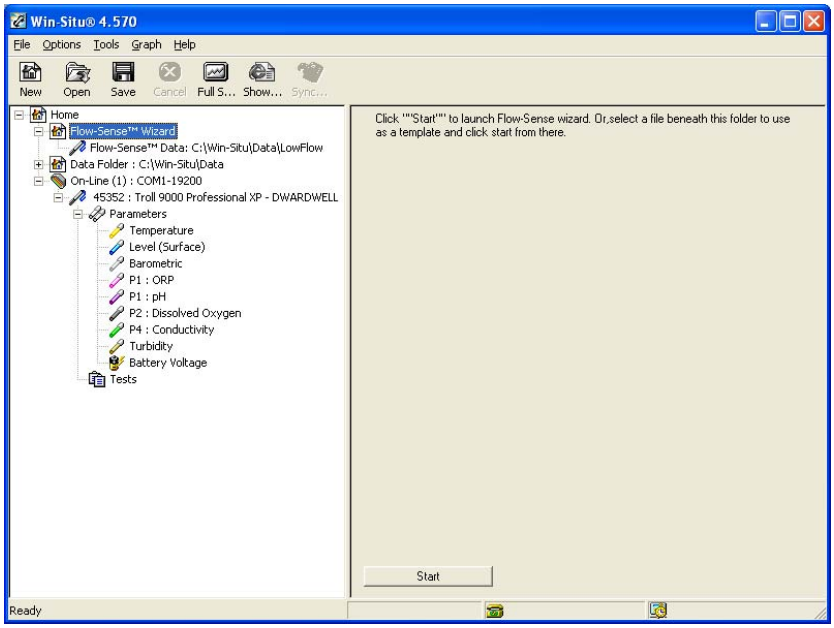
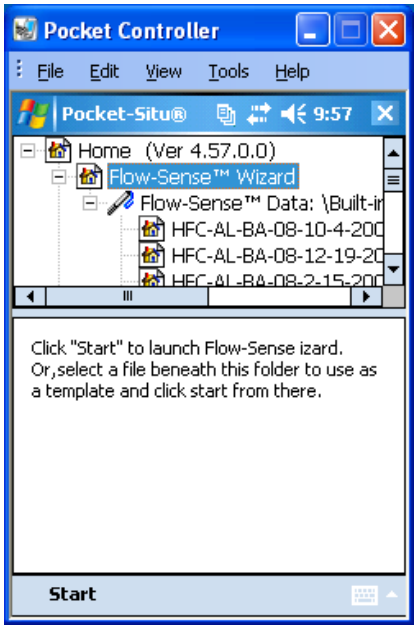
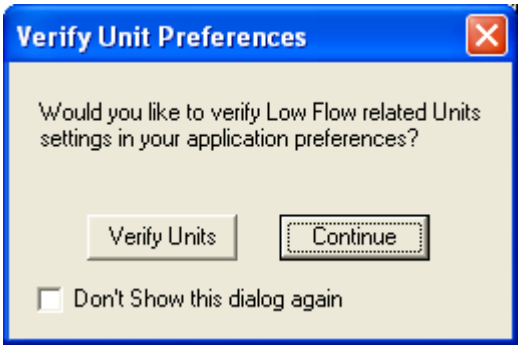
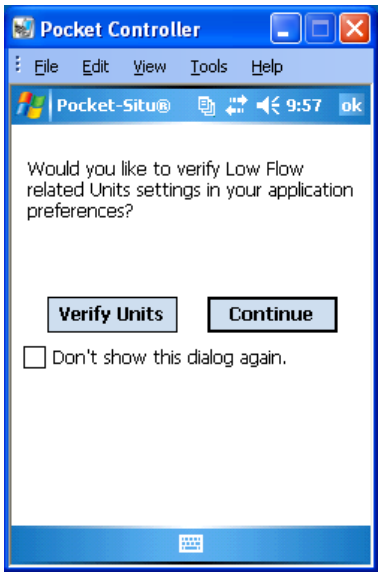
- The Troll 9500 with reset and your dashboard will reappear. You then want to highlight the **Flow-Sense Wizard**, and click **Start**.





- It is always smart to **Verify Units**, to make sure you are collecting data in the units desired for your project and reporting requirements.





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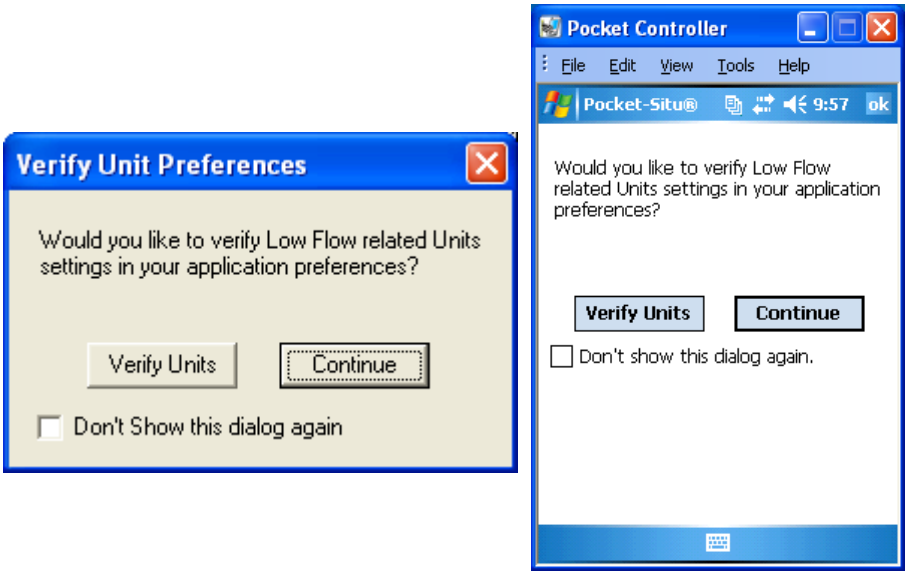
- Highlight each parameter and select the units you want, then click **OK**.



- The Flow-Sense software will open

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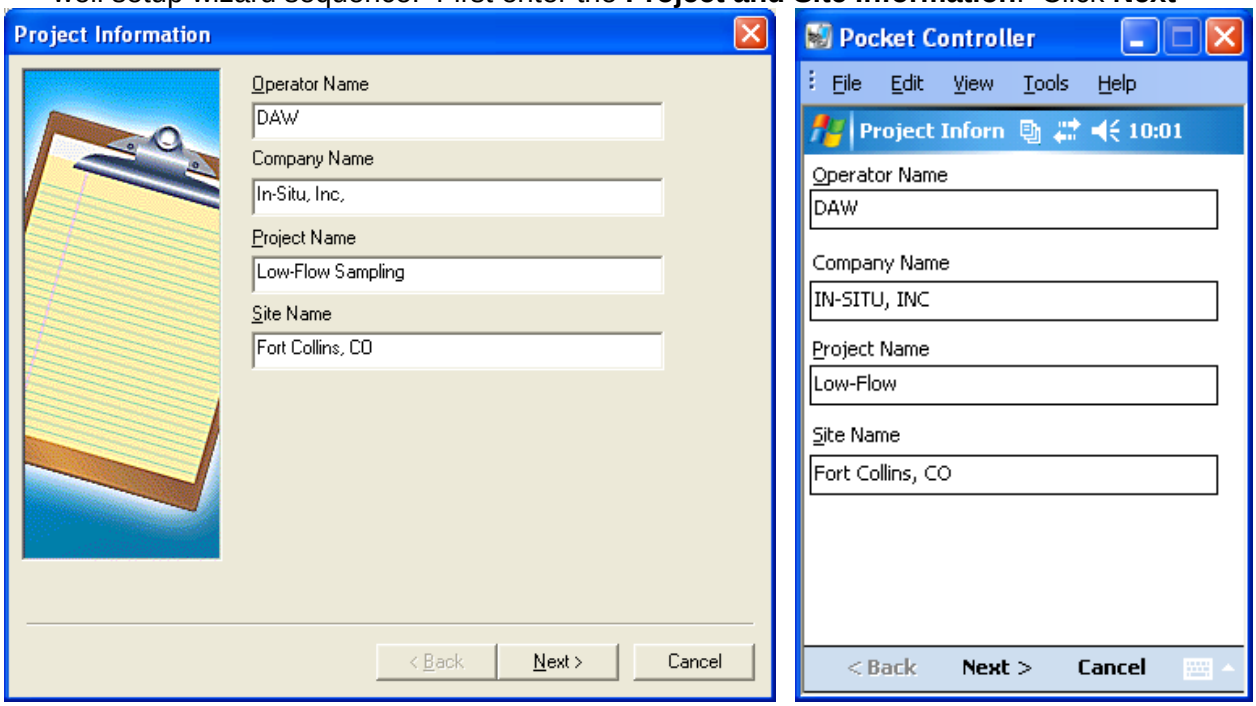
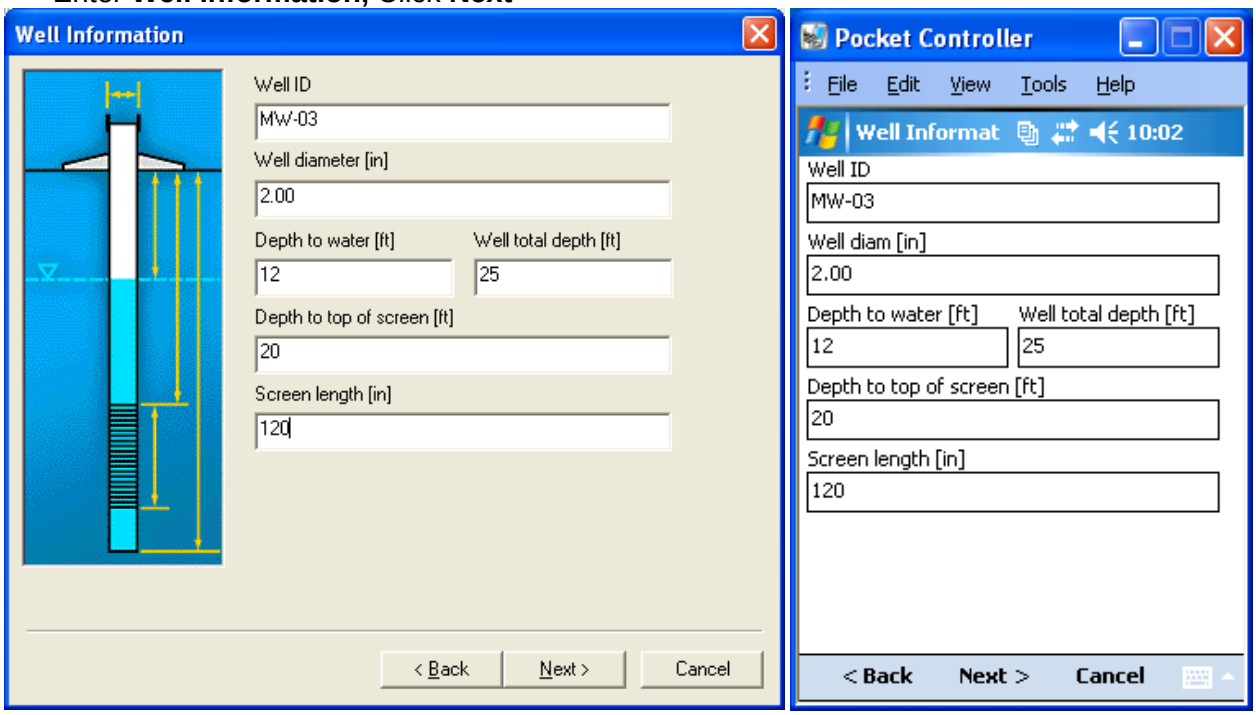
- To be most efficient, you should collect all the well sampling logs, sheets and info from your previous sampling events, then enter all the sampling project information in the Flow-Sense well setup wizard sequence. First enter the **Project and Site Information**. Click **Next>**



- Enter **Well Information,** Click **Next>**



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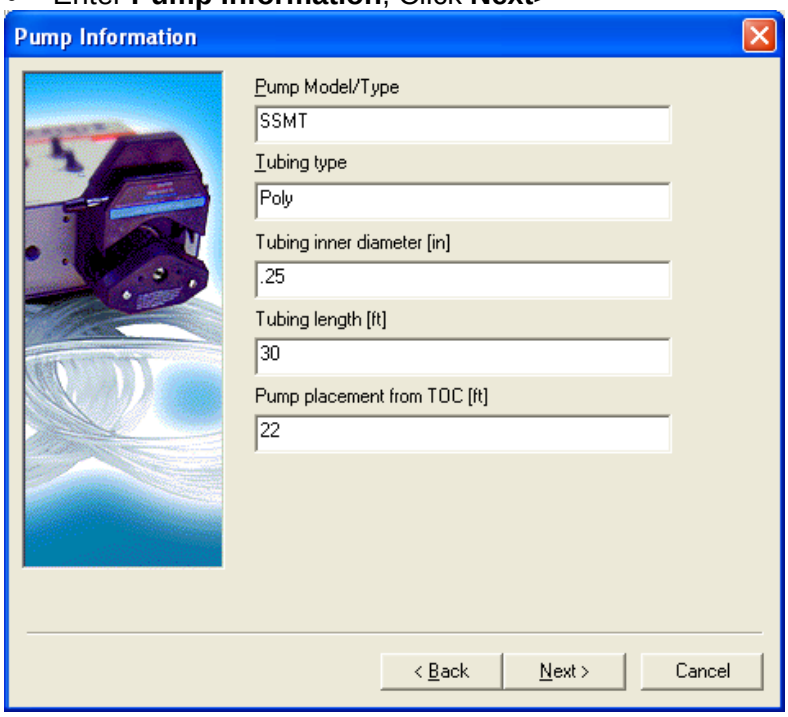
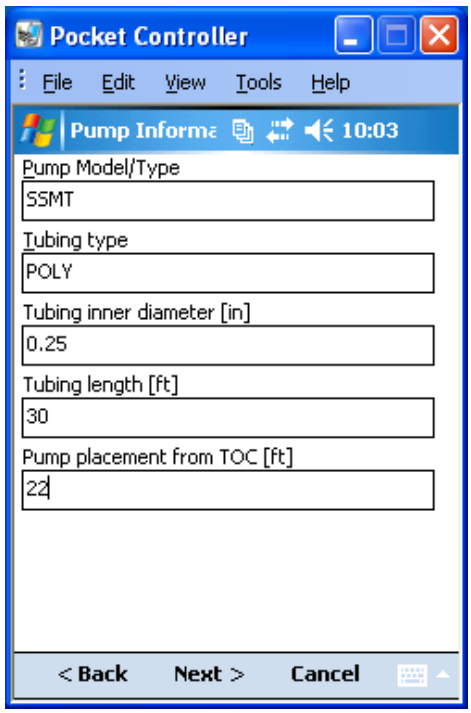
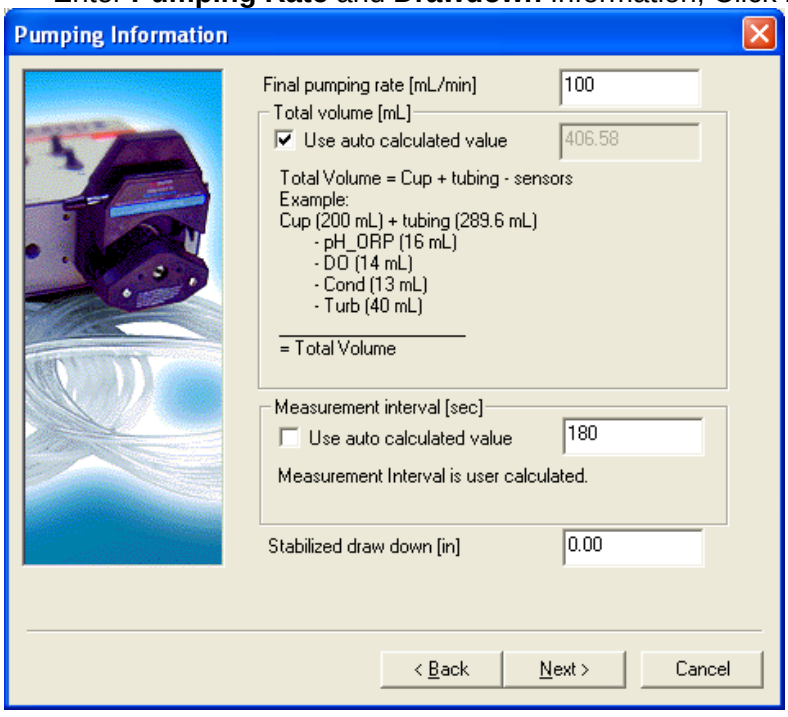
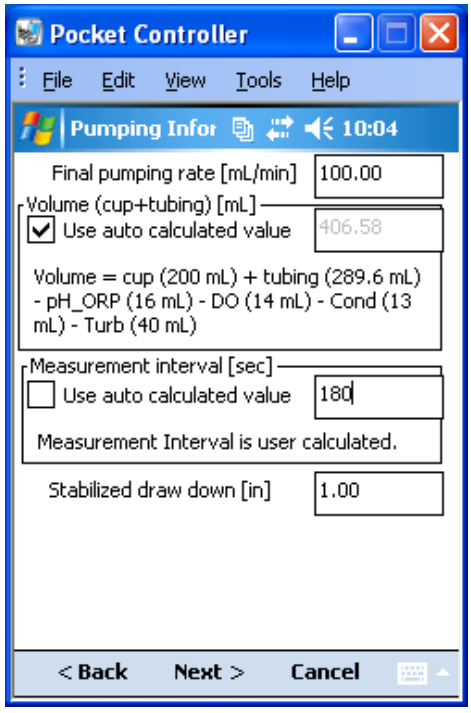
- Enter **Pump Information**, Click **Next>**





- Enter **Pumping Rate** and **Drawdown** Information, Click **Next>**





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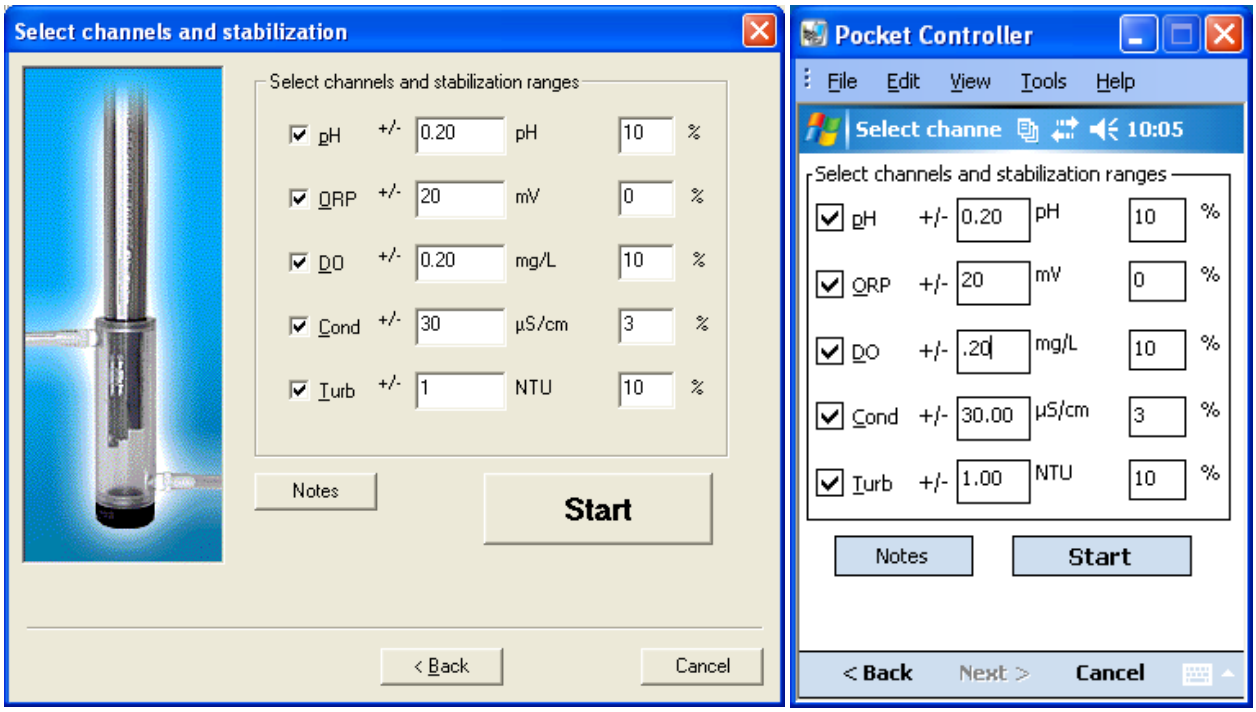
- **Select Channels** and enter **Stabilization Criteria**. This information should be in your sampling plan, but are listed below for help. You can enter the ASTM or EPA ranges here. Currently, if you want to use a percentage instead of a range, you must enter a range and a percentage, the program will default to the percentage. You can click on the **Notes** section to see or write down any information on the sampling event. Turbidity is not listed in this example, but the turbidity stabilization range should be ±1.0 NTU or 10%. You should not click Start until your flow and drawdown have stabilized. Once you are satisfied click **Start**.
- You can click the **<Back** button at any time to change your settings.



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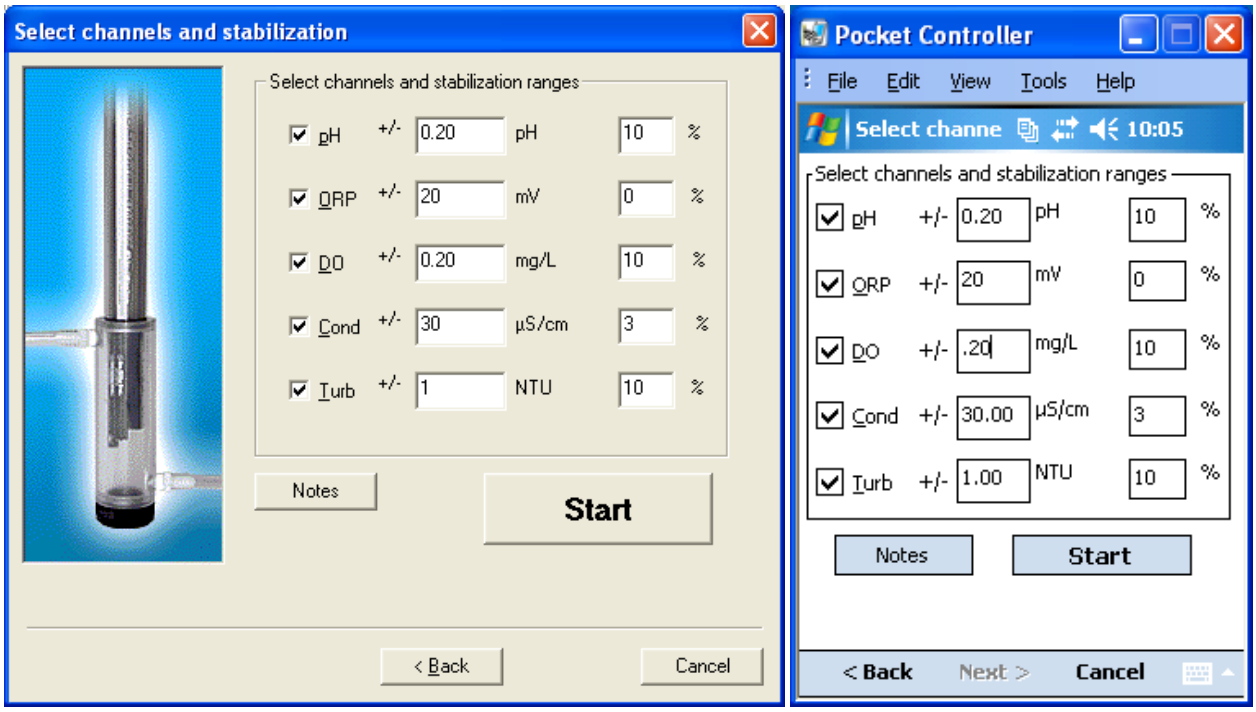
- Once you have started the **Water Quality Parameter Stabilization Sequence**, the following information is being collected. The left column records the latest water quality parameter reading. The right column lists the stabilization targets. The center column lists the current stabilization value.
- The software needs at least 3 WQ parameter readings in order to run a 3-point running average, and calculate your stabilization values. The For sample set (A, B, C) [(Max-Min)/A] X 100 = Running Average
- Included on this screen is the start time of the sampling event, the number of WQ readings collected so far, the total elapsed sampling time, and time left until the next readings are recorded.
- You have reached stabilization and can collect your groundwater sample once all the values in the center column and less than the values in the associated rows in the right column. Once this has been achieved, click **Accept**.



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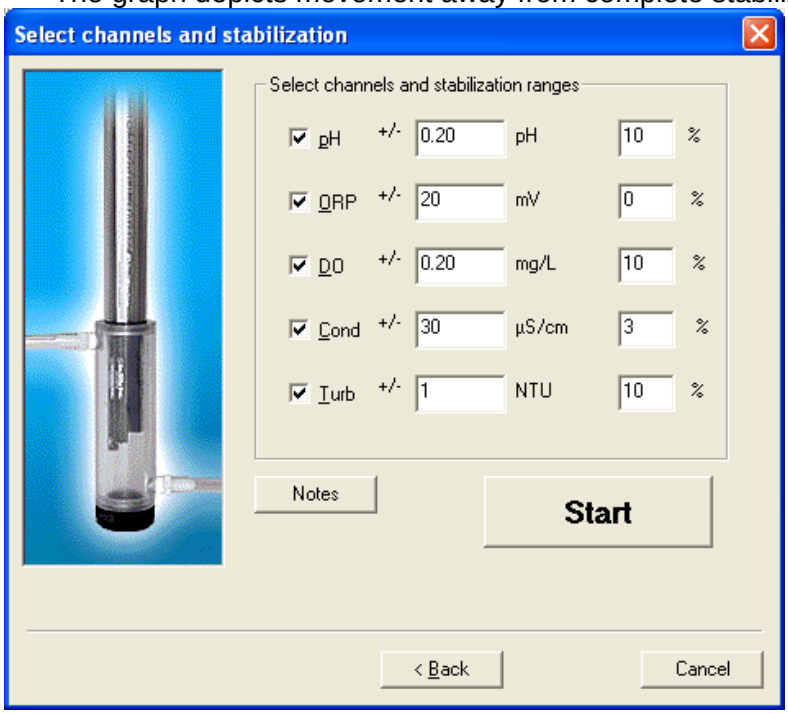
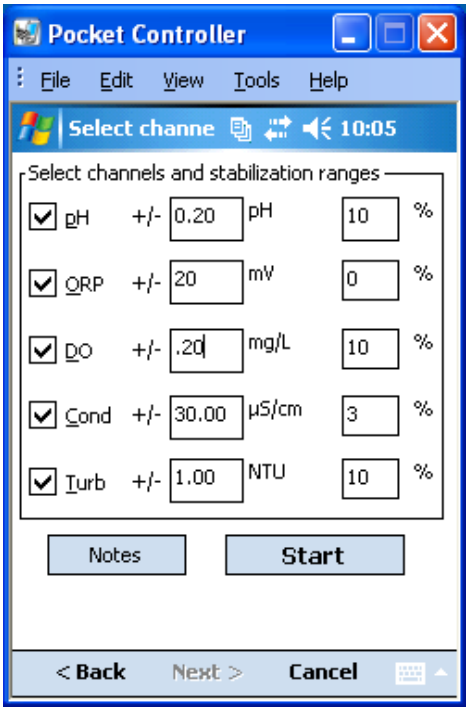
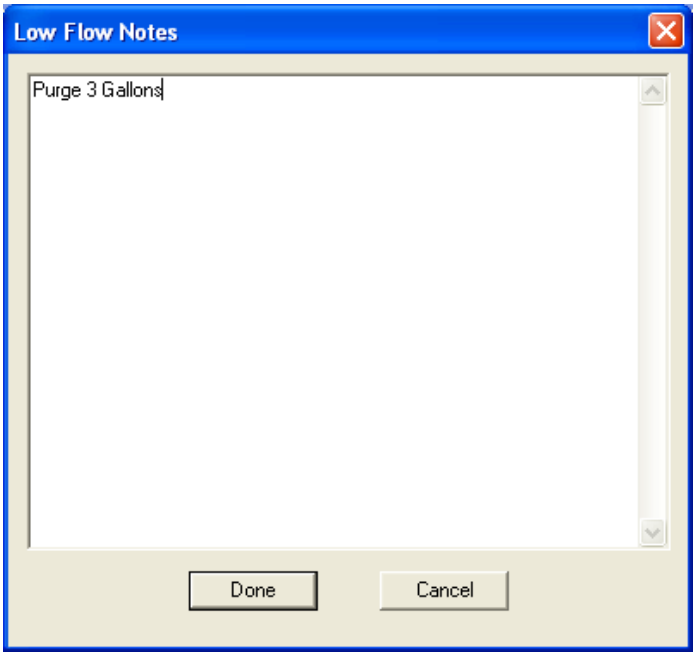
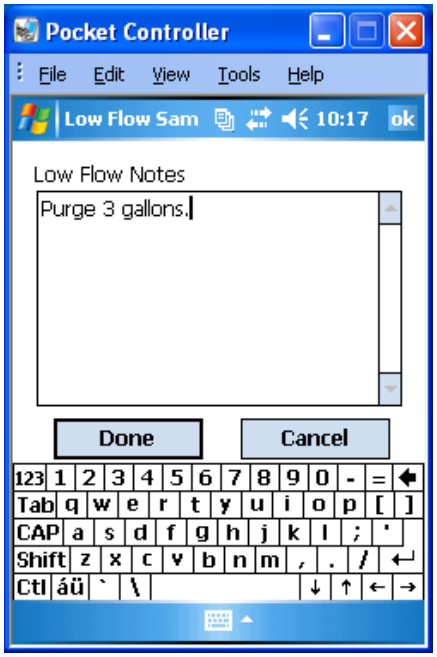
- You can click the **Graph** button to represent the stabilization readings in a graph format. The graph depicts movement away from complete stabilization.





- Once you accept the data and stabilization, a **Notes** section will automatically appear. Here you can input any info you want about the sampling event.





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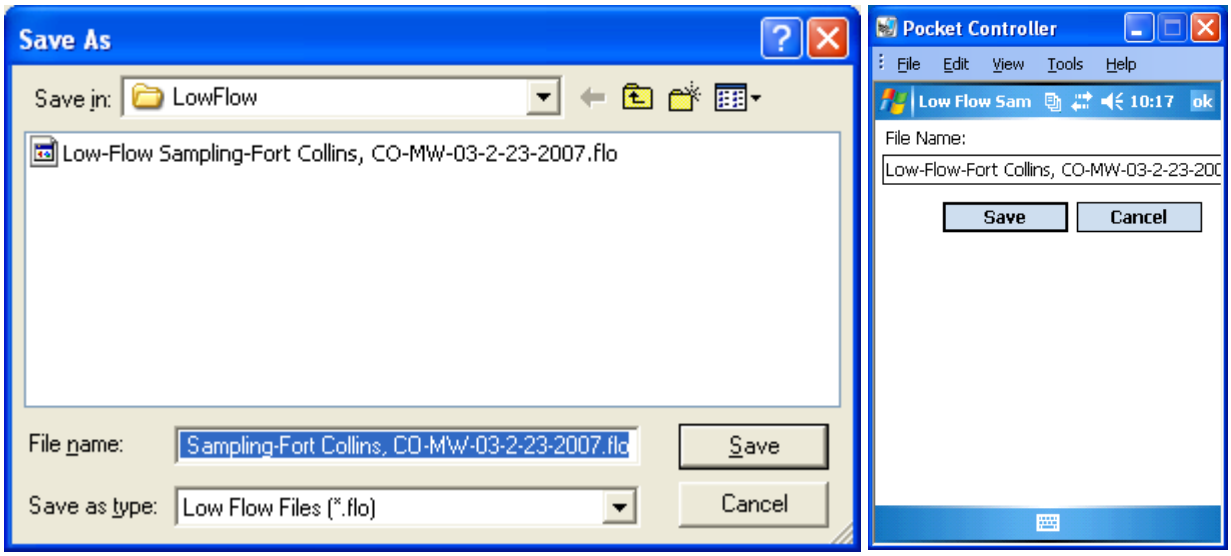
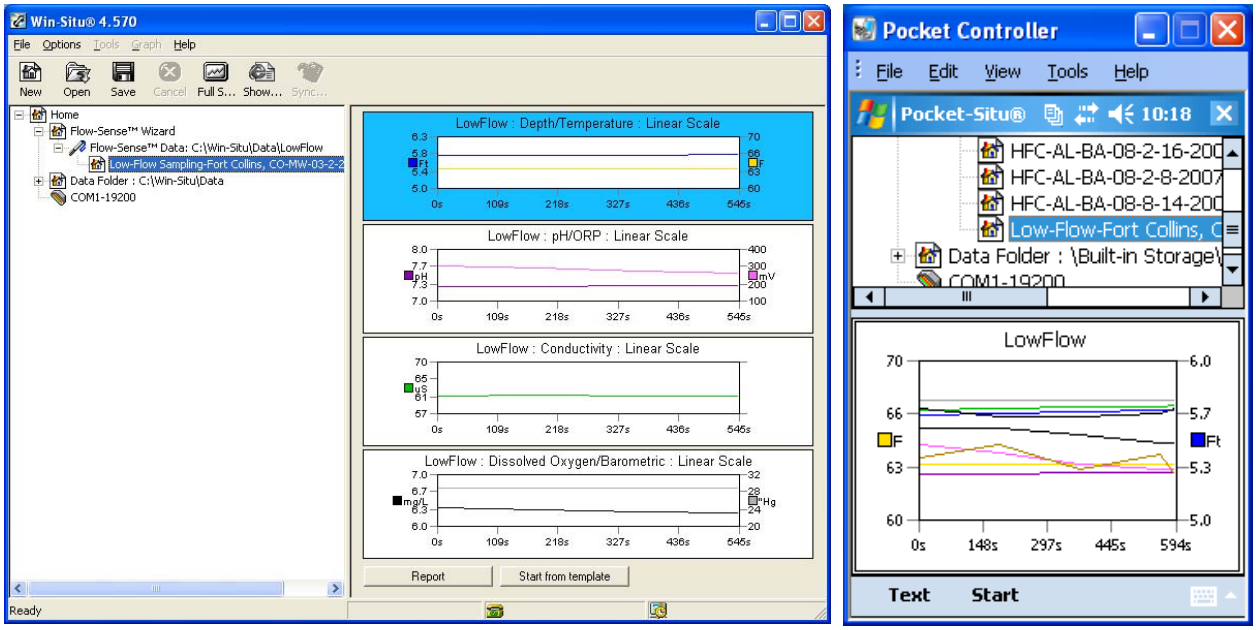
- The Save As screen will appear, and your sampling event will be saved automatically by (project, site, well ID, and date). You can also rename the file as you wish.



- The data file is automatically logged under the Flow-Sense data folder on the Win-Situ software, in alphabetical and chronological order.



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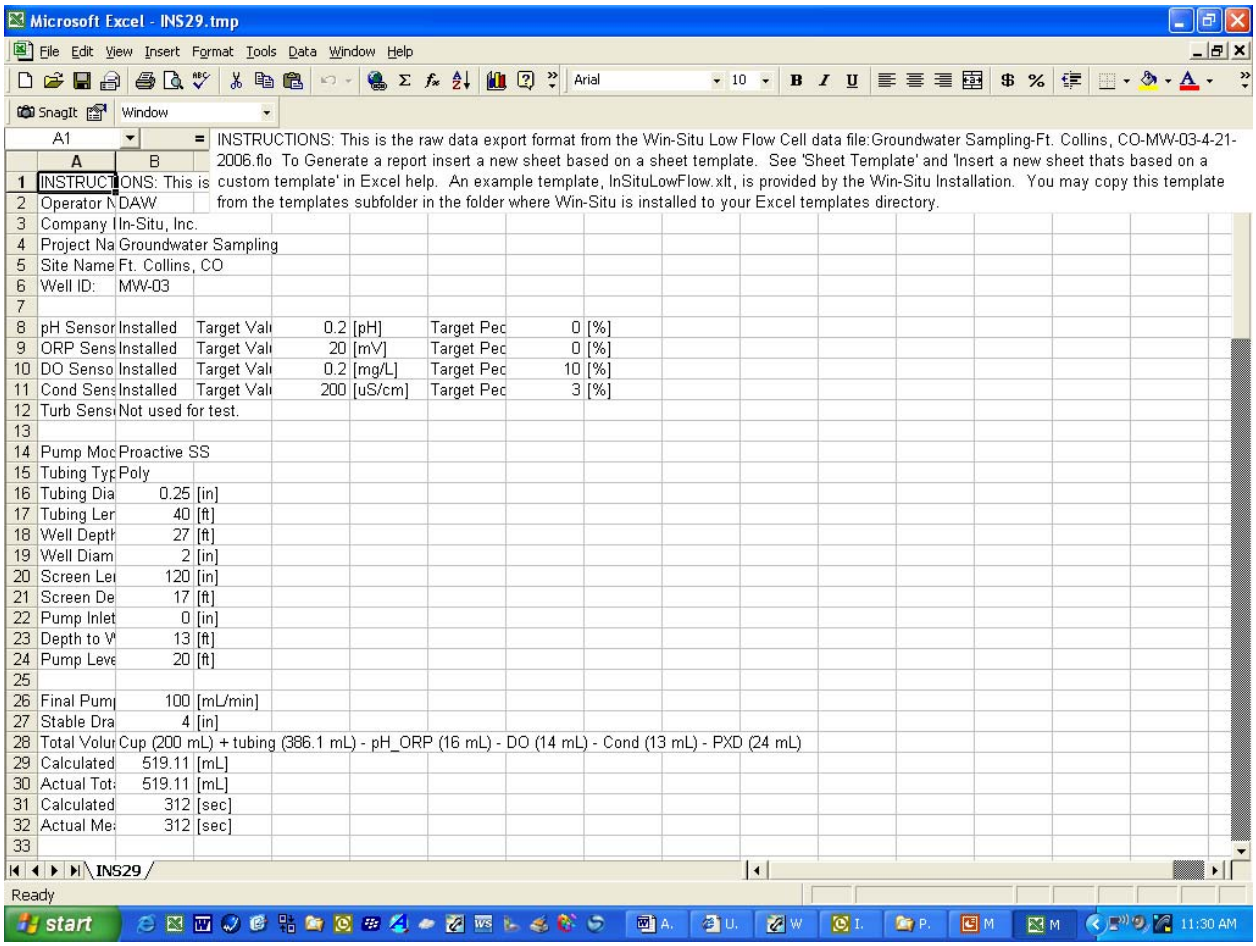
- To print up your groundwater data collection record for that well and day, simply highlight the sampling event desired, then go to **File**, and click **Export To Excel**.

- Your data is converted into Excel, but In-Situ Inc. has developed a formatted template that will organize all your data into one coherent data sheet. Simply right click on the data spreadsheet tab in the lower left corner of the screen and click **Insert**.



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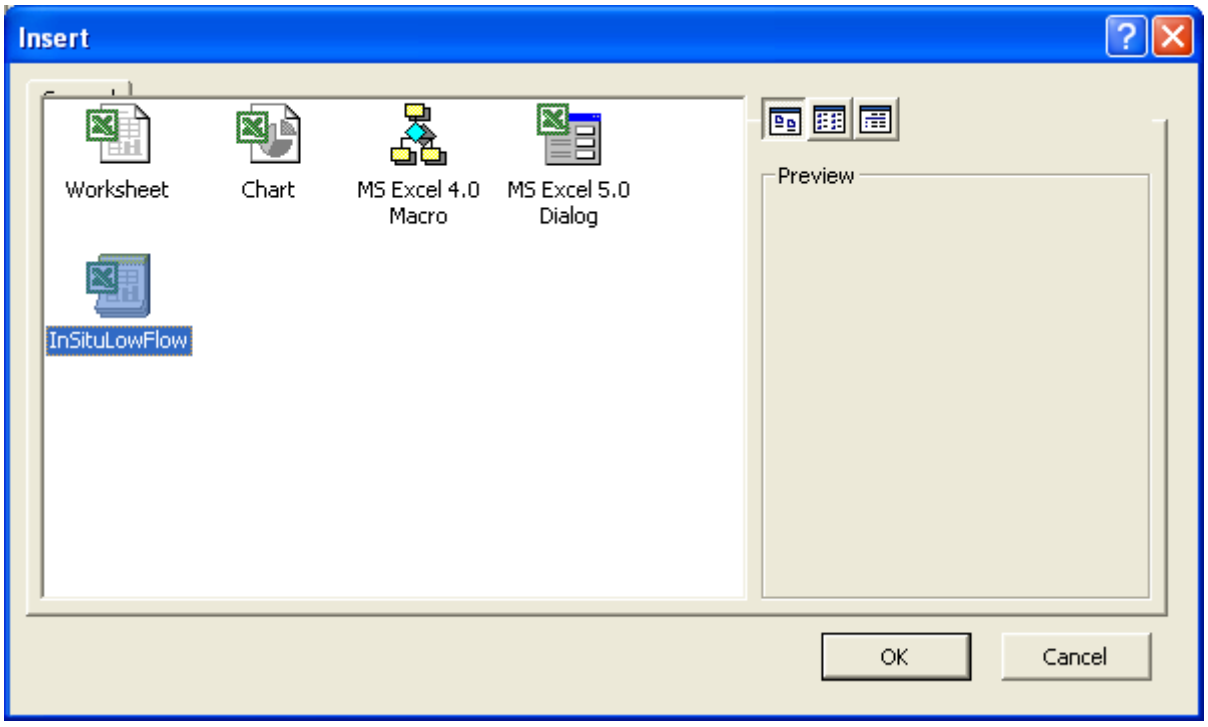
- A window will come up with your available Excel Templates, simply double click on the **InSituLowFlow** template to create your data sheet. You may have to locate the file “InSituLowFlow.xlt” in the "templates" directory located in your Win-Situ installationdirectory.



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- A formatted data sheet is created, that can be pasted or loaded into any sampling report.

In-Situ Inc. | Troll 9000 | Low-Flow System
04/21/06 | ISI Low-Flow Log

Project Information:

Operator Name	DAW
Company Name	In-Situ, Inc.
Project Name	Groundwater Sampling
Site Name	Ft. Collins, CO

Pump Information:

Pump Model/Type	Proactive SS
Tubing Type	Poly
Tubing Diameter	0.25 [in]
Tubing Length	40 [ft]
Pump placement from TOC	20 [ft]

Well Information:

Well Id	MW-03
Well diameter	2 [in]
Well total depth	27 [ft]
Depth to top of screen	17 [ft]
Screen length	120 [in]
Depth to Water	13 [ft]

Pumping information:

Final pumping rate	100 [mL/min]
Flowcell volume	519.11 [mL]
Calculated Sample Rate	312 [sec]
Sample rate	312 [sec]
Stabilized drawdown	4 [in]

Low-Flow Sampling Stabilization Summary

	Time	Temp [F]	pH [pH]	Cond [uS/cm]	Turb []	DO [mg/L]	ORP [mV]
Stabilization Settings			+/-0.2	+/-200 +/-3 %	+/- +/- %	+/-0.2 +/-10 %	+/-20
Last 5 Readings	10:42:56	69.81	4.81	1.32		13.70	399.18
	10:48:07	69.70	4.80	1.32		13.62	400.51
	10:53:20	69.62	4.78	1.32		13.51	401.53
	10:58:32	69.53	4.76	1.32		13.43	402.39
	11:03:46	69.24	4.76	1.32		13.42	403.03
Variance in last 3 readings	10:53:20	-0.08	-0.02	0.00		-0.10	1.03
	10:58:32	-0.09	-0.02	0.00		-0.09	0.85
	11:03:46	-0.29	-0.01	0.00		-0.01	0.64

Notes: Purge at 100 mL, at 5 minute intervals.

Total Volume purged was 2.3 Gallons.

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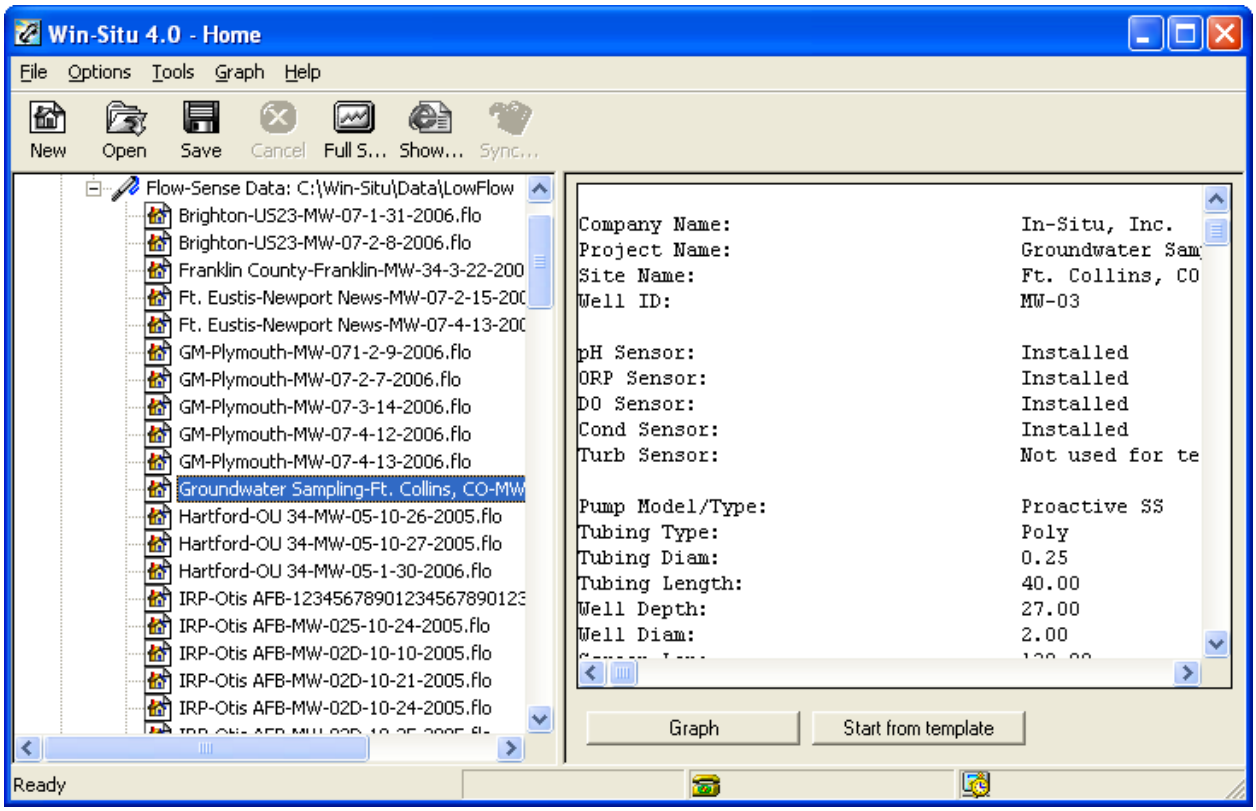
- Open up the Flow-Sense Data Folder and highlight the desired well, in order to sample the well again on another date. All information recorded during this sampling event will be reapeated in the future. **Click Start From Template**.



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References:

1. ASTM Guideline D6771-02, Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. (July, 2002). http://www.astm.org/cgibin/SoftCart.exe/DATABASE.CART/PAGES/D6771.htm

2. Puls, R.W. and Barcelona, M.J., Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, U.S. Environmental Protection Agency, Office of Research & Development, Publication # EPA/540/S-95/504 (1996). http://www.epa.gov/ahaazvuc/download/issue/lwflw2a.pdf

3. USEPA, Region 2, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells, (July 1996).http://www.epa.gov/Region2/desa/hsw/lowflow.txt

4. Douglas Yeskis and Bernard Zavala, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Publication# EPA/542/S-02/001 (May 2002). http://www.epa.gov/tio/tsp/download/gw_sampling_guide.pdf

These Guidelines are Federal and Regional Suggestions. Review with Local Regulator.

For Further Information Contact:

David A. Wardwell, In-Situ Inc. (www.in-situ.com), dwardwell@in-situ.com, 616-459-2849

In-Situ Inc. Technical Support (800) 446-7488