GWPD 16—Measuring water levels in wells and piezometers by use of a submersible pressure transducer

VERSION: 2010.1

PURPOSE: To make continuous water-level measurements in a well or piezometer by using a submersible pressure transducer.

Materials and Instruments

1. Vented submersible pressure transducer, data logger or data collection platform (DCP), cables, suspension system for the transducer and cables (wire ties or other semipermanent devices), and power supply
2. Data-readout device (i.e., computer loaded with correct software) and data storage modules or other media
3. Locked well cover or recorder shelter and key
4. A water-level tape (steel or electric) graduated in feet, tenths and hundredths of feet, and other materials necessary for depth-to-water measurement
5. Forms including:
    a. Well completion form
    b. Logbook with records of previous measurements for comparison
    c. Transducer calibration worksheet
    d. Water-level measurement field form or groundwater inspection sheet
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Calculator
8. Watch
9. Field notebook
10. Spare dessicant
11. Replacement batteries
12. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004)
13. Tools including:
    a. High-impedance (digital) multimeter
    b. Connectors
    c. Crimping tool
    d. Contact-burnishing tool or artist's eraser

Data Accuracy and Limitations

1. Water-level measurements for the in-place calibration of pressure transducers should be made to the nearest 0.01 foot.
2. The accuracy of a pressure transducer differs with the manufacturer, measurement range, and depth to water. The measurement error and accuracy standard for most situations are 0.01 foot, 0.1 percent of range in water-level fluctuation, or 0.01 percent of depth to water above or below a measuring point (MP), whichever is least restrictive.
3. Pressure transducers are subject to drift, offset and slippage of the suspension system. For this reason, the transducer readings should be checked against the water level in the well on every visit, and the transducer should be recalibrated periodically and at the completion of monitoring.

Advantages

1. Water levels can be collected at user-defined time scales without making individual manual measurements.
2. Small size allows water levels to be measured in wells or piezometers that are of small diameter, crooked, angled, or that contain pumps or other equipment.
3. The data logger can be left unattended for prolonged periods until data can be downloaded to a portable computer in the field.
4. Some pressure transducers with integrated data loggers are small enough to be placed inside the protective well casing and do not require a separate shelter. Good for high visibility, secure, or below-ground installations.
5. Downloaded data can be imported directly into a spreadsheet or database.
6. Can be interfaced with a DCP to transmit data collected via satellite for near real-time data reporting.
7. Can be installed in a flowing well.

Disadvantages

1. It may be necessary to correct the data for instrument drift, hysteresis, temperature effects, and offsets.
2. Transducers only operate in a limited water-level (pressure) range. The unit must be installed at the appropriate depth in a well so that the water level occurs within the measurement range of the pressure transducer. Wells with a large difference between maximum and minimum water levels may be monitored with reduced resolution using a pressure transducer with a higher range or may require frequent resetting of the depth of the transducer during site visits.
3. Materials in the transducer and cable may react with substances present in the water, causing damage or failure of the instrument.
4. Rapid water-level fluctuations may be missed if they occur between the programmed water-level measurement times.
5. With some data loggers, stored water-level measurements may be lost if the power supply fails.

Assumptions

1. A permanent MP has been established as described in GWPD 3.
2. The user is familiar with the transducer specifications and limitations and has evaluated the required accuracy of the measurements in accordance with the objectives of the study. The transducer's range is appropriate for the range of water levels expected in the observation well (the operating range will not be exceeded).
3. The transducer has been calibrated, either by the manufacturer or by the user, for the conditions expected in the field installation.
4. The transducer is vented to the atmosphere. Data from an absolute transducer must be adjusted to account for changes in atmospheric pressure.
5. If the user is visiting an existing installation, the vent tube is unobstructed, the desiccant is in place, and the well is free of obstructions.

Instructions

This procedure is limited to the installation of vented pressure transducers in observation wells and piezometers for long-term monitoring of water levels (fig. 1). For additional information, and for other applications, see Freeman and others (2004, p. 25–34).

1. If preparing a new installation:
   a. Check that the well is unobstructed. Clear obstructions as described in GWPD 6.
   b. If the well depth is not known, measure the total well depth as described in GWPD 11.
   c. If necessary, install an instrument shelter that will protect the transducer and data logger from vandalism and weather.
   d. Keep the transducer packaged in its original shipping container until it is installed. Connect the transducer, data logger, power supply, and ancillary equipment. Record the model, serial number, and pressure range of the transducer in the field notebook.
   e. Install the pressure transducer by lowering it into the well so that it is submerged below the water surface. Avoid dropping the transducer or permitting sharp contacts with the sides of the well casing. Do not allow the transducer to free fall into the well.

f. Conduct a field calibration of the transducer by raising and lowering it over the anticipated range of water-level fluctuations (Freeman and others, 2004, p. 29). Take three readings at a minimum of five intervals each, during both the raising and lowering of the transducer. Record the data on a calibration worksheet (fig. 2). Calculate a calibration equation for the transducer using the results in figure 2 and a regression equation. If a correction is necessary, apply the correction to the data logger or during post-processing of the water-level record.

g. The transducer should be installed at a point in the well that will not go dry. Estimate the lowest expected water level, and lower the transducer to the desired depth below the water level.

h. Fasten the cable or suspension system to the well head using tie wraps or a weatherproof strain-relief system. If the vent tube is incorporated in the cable, make sure not to pinch the cable too tightly or the vent tube may be obstructed.

i. Make a permanent mark on the cable at the hanging point so that future slippage, if any, can be determined.

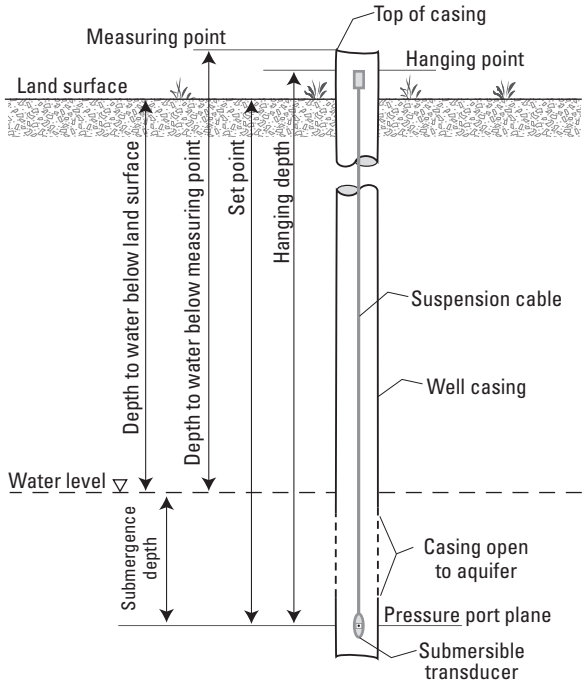

Figure 1. Submersible transducer in an observation well (Freeman and others, 2004, p. 27).

j. Record the well and measuring point (MP) configuration, by drawing a sketch (GWPD 3). Include the MP correction length above the land surface, the hanging point, and the hanging depth (fig. 1).

k. Measure the static water level in the monitor well with a steel (GWPD 1) or electric tape (GWPD 4).

l. Configure the data logger to ensure the channel, scan intervals, and other functions selected are correct. Activate the data logger and set the correct time.

2. If visiting an existing installation:

a. Retrieve groundwater data by using instrument or data logger software.

b. Inspect the equipment to confirm that installation is operating properly. Document the current water level recorded by the sensor (not the most recent water level recorded by the data logger).

c. Measure the depth to water in the well using either GWPD 1 or GWPD 4 to obtain an accurate water-level measurement to compare with the water level measured by the transducer.

d. Record the final water-level measurement on the Inspection of Continuous Record Well field form (fig. 3).

e. If the water-level measurement and transducer reading differ, raise the transducer in the well slightly and take a reading to confirm that the sensor is working. Observe for possible cable kinks or slippage. Return transducer exactly to its original position.

f. Recalibrate the transducer as described in part 1f if necessary (fig. 2).

g. If the water-level measurement differs from the instrumentation reading by an amount specified in the groundwater quality assurance procedures of the local office, record it on the inspection sheet and reset the instrumentation to reflect the proper depth to water.

h. Use the multimeter to check the charge on the battery, and the charging current supply to the battery. Check connections to the data logger, and tighten as necessary. Burnish contacts if corrosion is occurring. Check dessicant. Replace if necessary.

i. Verify the logger channel and scan intervals, document any changes to the data logger program, and reactivate the data logger. Make sure the data logger is operating prior to departure.

U.S. GEOLOGICAL SURVEY Data Processing No: _____
CALIBRATION WORKSHEET FOR SUBMERSIBLE TRANSDUCERS Page _____ of _____

Site Name: Official USGS site name Site ID and Number: 8 or 15 digit USGS Site ID

M.P. used: Nested piezometers often have multiple measuring points Party:

Date (mm/dd/yy): ___ /___ /___ Julian: _____ Watch Time: _____ EST CST MST PST Daylight UTC (circle)

Measuring Device: i.e. Calibrated steel tape, calibrated electric tape.

Transducer Information:
Date: _____ Type: _____ Length: _____ Serial No. _____ Output _____

Units of reading: mv, psi, ma Range: i.e.0-5 psi Conversion to feet: 2.3067 x psi = range of 0 to 11.534 ft.

Calibration marks: Describe what was used to mark the transducer cable for measuring distance moved during the calibration process.

Out-of water reading: _____ / _____ Set Point reading: _____ / _____ Scan Rate: _____ Reset? Yes No

Time	Measured Water Level	Cal. Mark	Dist. btwn. Marks	Total Dist.	Readings		
1014	22.35 DBLS		1.00		0.4334 psi		
1015		1		1.00	0.4337		
1016	22.35		1.50		0.4332		
1022	22.35				1.0838 psi		
1023		2		2.50	1.0841		
1024	22.35		1.50		1.0840		
1030	22.34				1.7341 psi		
1031		3		4.00	1.7337		
1032	22.34		1.50		1.7339		
1039	22.33				2.3843		
1040		4		5.50	2.3846		
1041	22.33		1.50		2.3844		
1047	22.33				3.0346		
1048		5		7.00	3.0342		
1049	22.33		1.00		3.0351		
1058	22.32				3.4682		
1059		6		8.00	3.4685		
1100	22.32		1.00		3.4678		
1106	22.32				3.0392		
1107		5		7.00	3.0388		
1108	22.32		1.50		3.0390		
1114	22.32				2.3887		
1115		4		5.50	2.3889		
1116	22.32		1.50		2.3891		
1120	22.31				1.7514		
1121		3		4.00	1.7516		
1122			1.50		1.7517		
1126	22.31				1.1011		
1127		2		2.50	1.1013		
1128	22.31		1.50		1.1010		
1134	22.31				0.4509		
1135		1		1.00	0.4507		WL rise of 0.04
1136	22.31 DBLS		1.00		0.4507		ft. during calib.

Figure 2. Calibration worksheet for submersible transducers (Freeman and others, 2004, p. 30).

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INSPECTION OF CONTINUOUS RECORD WELL
Steel Tape or Calibrated Electric Tape Measurement

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SITE INFORMATION

SITE ID (C1)

Measurement Tape ID _____ Date of Field Visit _____

Station name (C12) _____

	1	2	3
Time			
Hold			
Cut			
Tape correction			
WL below MP			
MP correction			
WL below LSD			

Measured by _____

Remarks _____

Barometric Pressure _____ Air Temperature _____

Battery Voltage _____ Replaced? Y / N

Measurement Method: Transducer Float

Checked Float/encoder? Y / N Checked Transducer? Y / N

DATA LOGGER VISIT INFO:

Local time: _____ GMT_____ Data logger time: _____

Sensor reading on arrival: _____ Sensor reading on departure: _____ RESET? Y / N

Datum Correction Needed: _____

Retreive data From: _____ To: _____
date/time date/time

Datafile: _____

Remarks: _____

MEASURING POINT DATA (for MP Changes)
M.P. REMARKS (C324)

BEGINNING DATE (C321) — month – day – year

ENDING DATE (C322) — – –

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

DATE WATER LEVEL MEASURED (C235) — month – day – year

TIME (C709)

STATUS (C238)

METHOD (C239)

TYPE (C243)

WATER LEVEL (C237)

WATER LEVEL TYPE CODE (C243): L M S
(L = below land surface, M = below meas. pt., S = sea level)

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measurement discon.,	obstruction,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign substance,	well destroyed,	surface water effects,	other	static

Figure 3. Water-level measurement field form for inspection of continuous record wells. This form, or an equivalent custom-designed form, should be used for continuous recorder inspections and field measurements.

Data Recording

All data times of measurement are recorded in the field notebook or trip log and on the Inspection of Continuous Record Well field form or water-level measurement field form. Depending on the type of data logger used, data from the data logger are transferred to the office computer via field computer or a data module.

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