State of Delaware
DELAWARE GEOLOGICAL SURVEY
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Delaware Geological Survey
Open File Report No. 51

DELAWARE GEOLOGICAL SURVEY GROUNDWATER MONITORING PROCEDURES PART 1: EQUIPMENT AND PROCEDURES FOR MANUAL AND AUTOMATED FIELD MEASUREMENT OF GROUNDWATER LEVELS IN DEDICATED MONITORING WELLS

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August 2018

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INTRODUCTION

The Delaware Geological Survey (DGS) has measured, managed, and distributed groundwater-level data for several decades using widely accepted procedures and practices, many of which were derived from interactions with staff of the USGS, consulting firms, and other state agencies. Many of the individual methods and procedures have been described in DGS reports, however, written documentation for these tasks have not been assembled in a single published document. The need for such a document has become more apparent with the development of standards for participation in the National Ground-Water Monitoring Network (SOGW, 2009).

This document describes methods used by the DGS for routine manual and automated measurement of groundwater levels in dedicated monitoring wells. Alternative methods used for manual measurement of water levels in other types of wells are noted in this document to provide reference for historical measurements but not described in detail.

These methods are excerpted and modified from procedures described by federal agencies and national standards organizations (e.g., ASTM, D4750-2007; Drost, 2005; USEPA, 2007). In this document, the term water levels will be used interchangeably with groundwater levels. Please refer to these and other appropriate documents for additional guidance or contact DGS staff with specific questions.

Practices pertaining to data processing and management, metadata, and quality assurance procedures for electronic data are rapidly evolving. Additional sections on these topics will be added to this document as time and resources permit.

MANUAL MEASUREMENTS OF WATER LEVELS

Figure 1 shows examples of equipment used for manual measurements of water levels. In the past 20 years, electric tapes have been used by DGS staff for manual measurements of water levels in dedicated monitoring wells more than 99.9 percent of the time. Steel tapes and other electric devices (i.e., m-scopes) were used in the past and so are described for reference purposes.

Figure 2 shows part of an example blank field data form for recording water level measurements and metadata. Customized forms that display the well identifier and other well-specific metadata are maintained for each routinely measured well. A form is made for each well and they are organized in three-ring binders and taken into the field. The measurement method is recorded in the remarks field if the electric tape method is not used.

Equipment list for Manual Readings

Water level measurement devices –

Electric tape – 0.01 ft or mm gradations (Fig. 1, A)

Other electric water-level sounder – 1 ft gradations or better (must use with folding engineering ruler) (Fig. 1, B, C)

Folding engineers rule 0.01 ft or mm gradations (Fig. 1, C)

Steel Tape – 0.01 ft or mm gradations (Fig. 1 D) (chalk, water level indicator paste)

Notebook and water level field sheets (Fig. 2)

Pencil, pen, and/or phone/tablet

Toolbox

Extra batteries

Timepiece synchronized to NIST-compatible timeserver

Personal protective items – gloves, boots, etc. (optional)

Dilute bleach solution (1:20) (as needed)

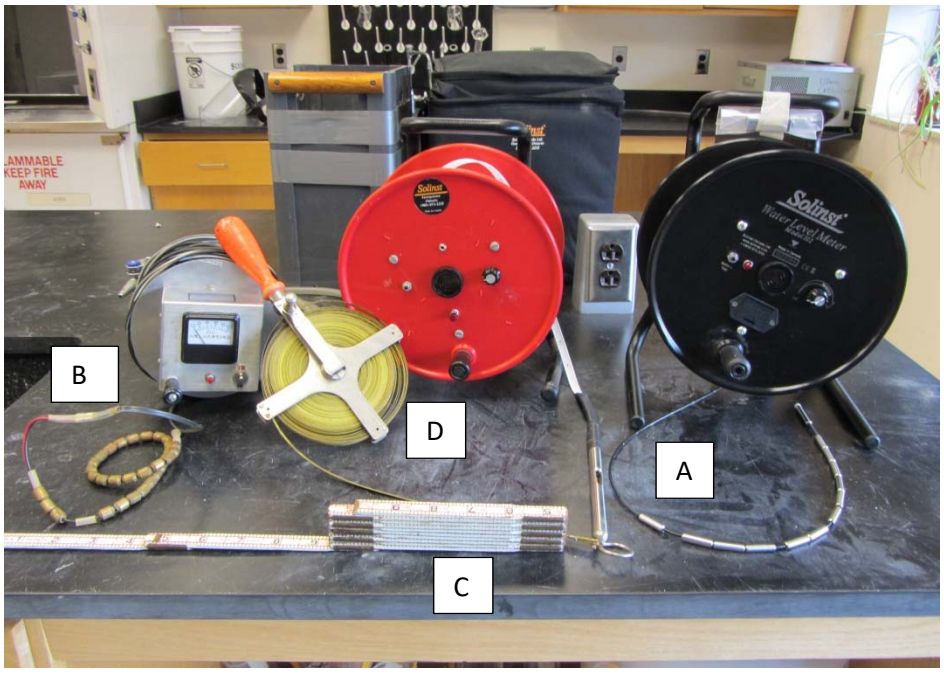

Figure 1. Photograph of devices used for manual measurement of groundwater levels.

DGS Well No. Db24-18 DNREC Permit No. 096246

Measuring Point Description Top of 2” well

Notes: Frogtown

Date	Time (EST)	Measured by (initials)	Water Level	REMARKS

Figure 2. Example of form used for recording manual measurements of groundwater levels at well Db24-18.

Step-by-Step Description for Manual Readings Using an Electric Tape or Well Sounder

1. Review documentation for well to identify measurement point and other specifics regarding well access and potential interferences with measurement. In almost all cases, an electric tape will be used for a monitoring well or other well with a large access port or open top. An electric water-level sounder may be used for miscellaneous measurements in a production or other well with small access port. Review the manufacturer's instructions for proper use of the electric tape. Steel tapes are only used in rare cases where the access port on the wellhead allows for insertion of the tape and the electric tape is not producing repeatable results. Detailed description of the steel tape measurement method is not provided in this document.

2. Switch the power on and check battery and operation of electric tape or electric water-level sounder with manufacturers recommended procedures. When using a steel tape, apply chalk or water level indicator paste to the lowermost 2 to 4 feet of the tape.

3. Slowly release the tape down the well casing, allowing the tape to slide over your outstretched hand or over a smooth and curved apparatus designed for that purpose and down the well.

   CAUTION: do not let the tape free fall because the line can give you a "burn" similar to a rope burn if it slides through your hand too fast or the tape may get stuck in the well.

4. Check the "feel" of the tape and robe. As the probe goes deeper, the weight should increase; if it does not, STOP lowering the tape —go to Step 7

5. Repeat steps 4 and 5 until the electric water-level meter indicates the probe is in water or if the probe becomes stuck or hung-up. When using a steel tape a splashing noise will indicate that end of the tape has reached water. Remember to check the "feel" of the tape about every 20 feet.

6. If you can no longer feel the weight, raise the tape slowly. Continue checking the tape to determine whether you have regained the weight of the probe. Once you can feel the weight again, begin lowering the probe very slowly. At the point when you cannot feel the weight, stop lowering the probe. Gently bounce the probe by raising and lowering the tape about two feet. This method may allow the probe to slide past the obstruction.

7. When the electric water-level meter indicates water by sound or light, check and make sure that this is a valid measure of the water level. Compare the level to previous measurements and to documentation of obstructions in the well. The indicator may be responding to due to cascading water, water drops on the inside of the well casing, or presence of salty conductive water in the well. When instrument sensitivity is set to a high level, cascading water, water drops, or salty water may cause the speaker or light to operate intermittently rather than a steady noise or light. Adjust the sensitivity switch to

a lower setting to minimize intermittent sound or light displays. Gently shake the tape to free the probe of water drops. If the intermittent signal continues, pull the tape out of the well and clean the probe and tape. If the meter still indicates presence of water then proceed to next step. During use of a steel tape, after hearing a splash lower the tape to the next whole foot gradation and hold the tape against the measurement point. This is the hold mark.

8. Raise the tape until the light or sound display stops. Lower the tape until the light or buzzer comes back on. Raise the tape until the light or sound display stops, and hold the tape in this position.

9. Now you will need to determine the water level measurement at the measuring point. Pull up the tape where you have held it to mark the water level measurement. Record the number that is just under your finger at this location near the measuring point. During use of a steel tape, retract the entire length of the tape and read the value of the gradation at the wet mark on the tape. Note that cascading water or presence of water drops on the inside of the well casing may require multiple attempts to attain a sharp, clear wet mark on the tape.

10. If the well is located far from a large capacity pumping well or in a confined aquifer it is necessary to check for water level changes due to slow equilibration. In this case, wait 30 seconds to one minute and repeat step 9. If the water level has not changed more than 0.03 ft then proceed to the next step. If the water level has changed more than 0.03 ft, then wait and repeat steps 8 and 9. Repeat this process until the water level has stabilized then proceed to the next step.

11. Record the water level record and measuring time on the field sheet (Fig. 2). NOTE: all times are recorded in East Standard Time not Daylight Savings Time. Make notes in the notes column on the field sheet regarding the amount elapsed between the first and final measurements, operation of nearby large capacity wells, etc., that may affect interpretation of the measurement.

AUTOMATED MEASUREMENT OF WATER LEVELS

Figure 3 shows examples of equipment used for the automated measurement of water levels.

Equipment list for automated measurement of water levels
Dataloggers – The term datalogger will be used to indicate both sensor/datalogger and sensor instruments. (Fig. 3, A)
Suspension or direct read cable – (Fig. 3, B)
Cable reel (Fig. 3, C)
Wellhead anchoring hardware (Fig. 3, D) – rings, clips, tape, etc.
Comm cable (Fig. 3, E)
Desiccant and desiccant capsules (Fig. 3, F)
Computer

Toolbox (Fig. 3, G)
Cleaning supplies
Manual water level measurement tools (Fig. 1)
Timepiece synchronized to an NIST-compatible timeserver

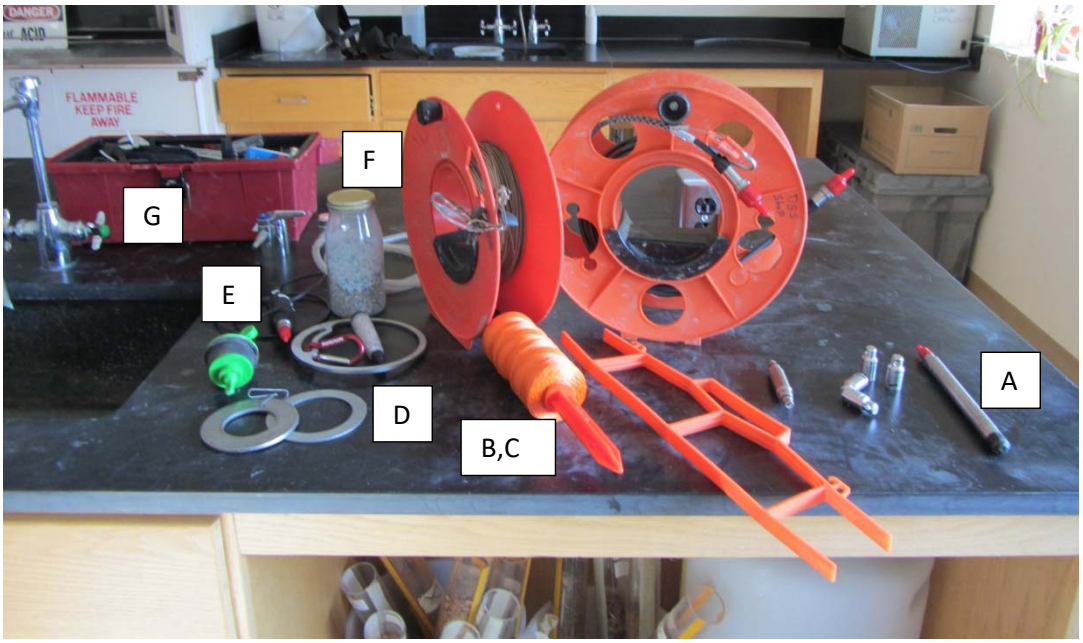

Figure 3. Photograph of equipment used for automated measurement of groundwater levels.

First time installation in a well or installation of a replacement instrument

1. Prior to leaving the office, review well metadata, experimental procedures, and staff notes to determine the appropriate tools and supplies needed to install the appropriate datalogger in that well. These considerations include the types of datalogger, length of suspension cable, communications cable, hardware to hang the datalogger in the well, and need for wellhead modifications. It is often useful to assemble all components, package them together in the office, and understand the field assembly procedures prior to travelling to the well.

2. Datalogger choice considerations: Range of water level fluctuations, desired accuracy, and if the datalogger is to be vented (relative) or non-vented (absolute).

3. Cable considerations: The cable should be long enough so that the datalogger will be located at an appropriate depth to monitor the full range of expected water level fluctuations. A vented data cable must always be used with a vented (relative) datalogger. A non-vented datalogger (absolute) can be suspended from either a non-vented data cable or a cord or wire attached to the dataloggers watertight top fitting.

4. Hanging hardware considerations: datalogger type (vented, non-vented), wellhead construction and limitations, type of cable or cord (vented, non-vented, cord), depth to water and weight of cable or cord.

5. Instrument, tests, and well metadata considerations: Accurate metadata records of the wells, tests, and instruments are necessary for maintaining valid data and efficiently performing field tasks. Creation and management of metadata must be coordinated among all staff and is best done in the lab prior to the instrument deployment.

6. Synchronize the computer clock against a NIST-compatible timeserver prior to leaving the office.

7. The following steps occur at the well site. Measure the depth to water. Use the procedures in "Manual Measurement of Water Levels" detailed above.

8. Assemble the datalogger, suspension or direct read cable, and hanging hardware according to the pre-determined design or modify if depth to water conditions are different than anticipated. Be careful to keep the assembly clean of dirt or debris and clean if necessary.

9. Launch the datalogger control software and connect the computer to the datalogger/cable system through the appropriate comm connector.

10. Using the datalogger control software, synchronize the datalogger's clock with the computer clock.

11. Using the datalogger control software, view the real-time pressure data to ensure that the probe is functioning.

12. Using the datalogger control software, assign the correct site information to the datalogger.

13. Using the datalogger control software, program a new test into the datalogger.

    a. Name the test with *filename format DGSID_YYMMDD(e.g. Db24-18_120118*
    b. Select appropriate measurement types to record
    c. Set recording interval according to specifications for the well
    d. Set scheduled start to the nearest quarter hour from the current time. If it is 8:56 set the start time to 9:00 OR set manual start and start the test.
    e. Review the test settings and adjust as necessary

14. Steps 14- 18 are for installations with direct read cable. For other types of installations, proceed to step 19. Carefully lower the datalogger into the well. View real-time data from the datalogger. Check to see if the datalogger is at the desired depth; if not, adjust appropriately.

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

15. Once the desired depth is reached, secure the cable inside the well or to a wellhead-mounting device. If appropriate, anchor and mark the suspension cable with electrical tape at the wellhead-mounting device. Doing this documents cable placement and allows for detection of cable slippage or tampering.

16. Using the datalogger control software, enter the starting or reference water level.

17. Make one additional manual water level measurement to confirm that the well has recovered from the insertion of the probe and suspension cable. Review the specified test data, modify the test specifications, and start the test as needed.

18. Disconnect datalogger from software and comm connector; secure the top connector data cable with dust cap or watertight connector.

19. Proceed to step 20 for installations with direct read data cable. Using the datalogger control software, enter the starting or reference water level, start test if necessary. Disconnect datalogger from software and comm connector. Install watertight connector to datalogger, attach pre-measured suspension cable or cord, attach suspension cable to wellhead anchor and carefully lower the datalogger into the well. Refer to caution notes in step 14.

20. Close and secure wellhead. If possible, ensure that the well has sufficient venting to allow the well water to be in contact with the atmosphere.

Data retrieval

On the day before or on the day of travel, synchronize the computer clock with a recognized time service.

1. Travel to the site and open the well

2. Measure the depth to water at the pre-determined measurement point using the procedures in Manual Measurement of Water Levels.

3. Record the water level, measurement point, and time in your field book, phone or tablet.

4. Start the computer, log in, and launch the appropriate datalogger control software

5. Connect the datalogger to the computer using the appropriate comm cable. The software will display real time data when communications have been established. Consult the software manual or call the office for troubleshooting communication problems.

6. Using the datalogger control software, download the test from the datalogger to the computer.

7. Using the datalogger control software, review the test file using the instrument software to see if any data were collected and retrieved. If no data were collected then review the data file header to learn what went wrong.

8. Delete the test file and clear the datalogger memory by deleting the test definition.

9. Follow steps 10-20 in the previous section as appropriate.

REFERENCES CITED

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