Quality Assurance Project Plan for WRIA 53 - Lower Lake Roosevelt Watershed Groundwater Level Gauging Program: Northern Lincoln County, Washington

Prepared for:

WRIA 53 - Lower Lake Roosevelt Watershed

Prepared by:

Water & Natural Resource Group, Inc.

GSI Water Solutions Inc.

November 18th, 2009

Quality Assurance Project Plan (QAPP) for WRIA 53 - Lower Lake Roosevelt Watershed Groundwater Level Gauging Program

Prepared by

Eugene N.J. St.Godard, P.G., LHG.
Water & Natural Resource Group, Inc.

And

Kevin Lindsey, Ph.D., LHG.
GSI Water Solutions, Inc.

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Approvals:

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Eugene N.J. St.Godard, WRIA 53 - Watershed Coordinator Date

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Kevin Lindsey, GSI Water Solutions, Project Manager Date

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Jim DeGraffenreid, Lincoln County Planning Director Date

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David Lundgren, Lincoln County Conservation District Manager Date

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Jaime Short, Department of Ecology WRIA 53 Project Manager Date

Section 1
Introduction and Background

This document presents a Quality Assurance Project Plan (QAPP) for planned groundwater data collection for the Lower Lake Roosevelt Watershed (WRIA 53) Groundwater Level Monitoring Project. Elements of this QAPP include methods and procedures for collecting water level measurements from wells.

The Groundwater Level Monitoring Project is funded by a watershed grant from the Washington State Department of Ecology (Ecology) for the 2010 FY, under grant number G0800258. The overall general objective of the Monitoring Project is to develop a database of groundwater levels in the three distinctive aquifers that WRIA 53 can use on a long-term basis for scientifically-based water resource management and planning activities. Specific objectives include refining hydrogeologic models, identifying local groundwater flow systems, and quantitatively evaluating regional-scale and local-scale groundwater occurrence, movement, recharge, and discharge. Data can subsequently be used for future land use management decisions based on availability of groundwater resources.

Section 2
Project Description

This QAPP summarizes procedures and quality assurance protocols for collecting groundwater level measurements to determine aquifer properties, specifically to determine if fluctuations (seasonal or sustained) in the groundwater table are occurring. These data will used to refine the conceptual hydrogeologic model developed by the Subsurface Geologic Mapping and Hydrogeologic Assessment Project that was conducted by the GWMA under legislative funding during the 2007-2009 biennium, for that area specifically lying within WRIA 53. These data will not be used for regulatory purposes. The data are intended for the use of the WRIA 53 Planning Unit, which includes local agencies, landowners, and water resource users within the watershed.

The general scope of the Monitoring Project is as follows:

1. Collect data for the purpose of constructing a groundwater level database for the WRIA 53 watershed.
2. Use the data to further refine the existing geologic conceptual models of the basalt, granitic and unconfined aquifers within WRIA 53.
3. Create a three-dimensional conceptual groundwater flow model for the three hydrogeologic systems, using the data collected.

4. Determine if aquifers may be under stress from existing groundwater withdrawals.
5. Using the collected data to assist with local groundwater management issues.

Integrated with this project approach will be the use of the new data to address the following three primary questions contained in the funding legislation:

(a) The fluctuation of groundwater levels within the three aquifer systems in WRIA 53. The collection of groundwater level data will assist with the development of a three dimensional conceptual model of the aquifers. This representation will include the seasonal variability of the groundwater tables, if present, or if potential long range dropping of the water table will occur.

(b) The location of aquifer recharge and discharge. The groundwater level monitoring will allow an interpretation of flow directions in each of the hydrogeologic systems, allowing interpretation in the conceptual model for the identification of recharge and discharge areas at regional and local scales (which are two critical components of future groundwater flow modeling).

(c) Potentially viable solutions to observed problems in specific areas of concern. For identified local groundwater systems exhibiting potentially declining water tables, the data will be used for future groundwater and land use management.

As described in scope of work for the Groundwater Level Monitoring Project, the findings of the evaluation of these three primary questions will be presented in several deliverables.

Section 3
Organization and Schedule

This QAPP was prepared for the WRIA 53 Planning Unit by Water & Natural Resource Group, Inc. (WNR Group) and GSI Water Solutions, Inc. (GSI). This QAPP focuses on the collection of hydrogeologic data, specifically water level data collected from wells throughout the watershed. This QAPP was prepared in general accord with the guidelines presented in Ecology Publication No. 04-03-030.

3.1 Organization

WNR Group, supported by its primary subcontractor GSI, will act as the lead investigators for the Groundwater Level Monitoring Project under the direction of the WRIA 53 Planning Unit and contracted through Lincoln County. The Lincoln County Conservation District (LCCD) will conduct the field activities under their MOU with Lincoln County and the supervision of Gene St.Godard, L.Hg., and Dr. Kevin Lindsey, L.Hg. Gene St.Godard will serve as the project manager and principal investigator for the consultant team. Mr. St.Godard is responsible for seeing that quality assurance goals on the Project are met and as project manager reports to Mr. Jim DeGraffenreid, Director of Lincoln County Planning and subsequently to the WRIA 53 Planning Unit. Mr. Jim DeGraffenreid of Lincoln County Planning has overall fiscal oversight and contract management responsibility under WRIA 53 grant contract with Ecology. For

LCCD, the district manager, Mr. David Lundgren will coordinate the field technicians for the field monitoring program. LCCD staff under the direction of Mr. David Lundgren will lead data collection activities described in this QAPP.

Key overall project responsibilities of each of the project participants are defined below:

1. WRIA 53 Management: Mr. Jim DeGraffenreid, Director of Lincoln County Planning, Lincoln County Board of County Commissioners
    a. Responsible for oversight of all WRIA 53 projects.
    b. Responsible for the decision and policy making process which guides project activities and day-to-day operations of the WRIA 53 Groundwater Level Monitoring Project.
    c. Responsible for overall project budget tracking and periodic reporting to Ecology.

2. WNR Group & GSI
    a. Lead investigator in charge of project organization
    b. Track consultant budget expenses and make every reasonable effort to accomplish the project within approved budget.
    c. Prepare sampling plans, including this QAPP.
    d. Assist in development of spreadsheet databases in which data collected for the project is stored, perform data entry.
    e. Plan and conduct oversight activities of the hydrogeologic data collection.
    f. Conduct evaluation, and data validation activities as determined by the project scientific team.
    g. Oversee the progress of data collection, evaluation, and database compilation; provide project oversight; and check data validity.
3. LCCD
    a. Conduct field data collection.
    b. Notify WRIA 53 Management regarding unplanned activities or unforeseen circumstances affecting project data collection.
    c. LCCD field staff will be trained by WNR Group and GSI and will work under sampling plans prepared by the project hydrogeologists (St.Godard and Lindsey).

In addition to these formal roles and responsibilities, the WRIA 53 project team is in regular communication with Ecology staff to share data and insights into the hydrogeology of WRIA 53 and surrounding area. While Ecology staff members are not a formal part of the WRIA 53 team, we anticipate continued discussions with them, to include but not be limited to, data sharing and peer review.

3.2 Schedule and Limitations

The general project schedule for the Groundwater Level Monitoring Project is described in the project work plan and summarized here. We anticipate that field data collection work done under this QAPP will begin in December 2009 or January 2010, and continue through June 2011, if funding is continued. Current funding allows for monitoring through June 2010. The actual project schedule will be dictated by data collection needs associated with watershed planning

efforts, actual conditions encountered in the field, and new information and insights into the WRIA 53 groundwater conditions as the work proceeds.

3.3 Budget and Funding

Funding for this project is provided by a watershed planning grant to WRIA 53 from Ecology for the 2010 FY, under RCW 90.82. Project funding is being distributed to Lincoln County Planning (lead agency for WRIA 53) per monthly invoices billed on a time and expense reimbursement basis.

Section 4
Quality Objectives

The primary objective of this study is to collect water level data to determine hydrogeologic characteristics of the three hydrogeologic regimes in WRIA 53 and to support the refinement of the conceptual hydrogeologic model for the watershed. Data objectives will also be utilized for the development of future water resource management decisions and planning efforts.

4.1 Water Level Measurements

The goal of the WRIA 53 Groundwater Monitoring Project is to collect measurements in 50 to 75 wells throughout the watershed. Wells which do not have any pumping equipment in the well will be prioritized for data collection, so a true static water level can be measured. WRIA 53 anticipates that some wells will contain pumping equipment and water level measurements will be collected for both static and dynamic pumping conditions. Measurement accuracy of 0.1 feet will be attempted in each of the wells monitored. Measurement accuracy of 1.0 foot will be sufficient for wells with airline measuring devices.

The representativeness of new water level data collected for the Monitoring Project will be based on the measurements being taken from water wells where the technical team can determine the depth and elevation of the open interval(s) within the well, and the geologic unit(s) that open interval corresponds to. The open interval of a well is defined as the interval(s) that is in direct hydraulic communication with the aquifer such that the water level measured in the well is affected by stresses within that interval. In WRIA 53, this interval commonly consists of the open borehole and any cased interval in connection with the open borehole in which a cement or bentonite seal is not present. Open interval depth and elevation will be established using written records and invasive data (such as well videos) provided by the well owner and/or other sources. Geologic unit interpretation will be based on that information and the GWMA's previous subsurface geologic mapping efforts.

Electronic water level sounders will be the primary tool used to measure and record water level data. Where access limitations preclude measurement using a water level sounder or transducer, and a functioning airline is present, the water level will be measured using the airline. Depending on which instrument is used, water levels will be measured with an accuracy and precision of 1.0 to 0.01 feet. The accuracy and precision will be based on the type of instrument used in any

particular measurement event. The type of instrument used will be dictated by accessibility considerations. In all cases, the specific measurement device used and any special circumstances affecting the accuracy and precision (e.g., cascading water) will be recorded in the field notebook so that the precision of the measurement can be assessed. For project planning purposes the main measurement techniques and their associated precision currently anticipated are as follows:

1. Solinst/Slope Indicator/Waterline e-tape – 0.01 foot.
2. Powers e-tape – 0.2 feet.
3. Sonic water level indicator – 0.1 foot
4. Airline – depending airline and gauge condition and the scale range on pressure gauge. This will generally range from 1 foot to 5 feet.

Completeness will be evaluated by collecting multiple water level data over time during the Project. This will allow WRIA 53 to assess variability in the data and whether an adequate amount of data has been collected.

4.2 Well Locations and Wellhead Elevations

All wellheads will be surveyed for horizontal and vertical control using a hand held GPS unit and comparison to 7.5 minute topographic maps. At each well, the ground surface at the well and water level access port will be surveyed. Unless noted otherwise in field notes, the water level measuring point will be the access port on the top of the well casing. Horizontal accuracy will be within 20.0 feet and the vertical accuracy will be within 5 feet, to the extent possible given instrument accuracy and map accuracy.

Section 5
Study Design – Water Level Measurements

This section of the QAPP describes the purpose and scope of the various elements of the water level measurement program.

5.1 Water Level Measurements

WRIA 53 plans to collect water level measurement from 50 to 75 wells within WRIA 53. Currently, approximately 40 property owners have volunteered access to their wells for the monitoring program. These wells will be reviewed for geologic conditions and a good distributive selection of wells will occur. Due to the time constraints of the Project, wells will be selected as the project proceeds, and a final list of selected wells will only be developed at the end of the Project. This portion of the QAPP is therefore focused more on methods and procedures to be used in selection, sampling, and analysis, rather than providing a list of sampling locations.

The following selection criteria will be used to identify candidate wells to be used for measuring water levels for the Modeling Project:

- Candidate wells will have known geology (e.g., have a geologic log) and well construction details.
- Possible surface water recharge sources, other measurement points, and known or suspected pumping wells relative to candidate wells will be identified.
- The candidate well must be physically accessible and have a sampling port or other suitable opening to use to collect data of sufficient accuracy and precision to be usable for the project.
- The well owner must give permission to WRIA 53 for the well to be monitored.

An initial list of candidate wells will be compiled by WRIA 53 investigators using WRIA 53's subsurface geologic well log database, subsurface geology maps, and personal contact. This initial list will be based on the first two criteria listed above. The last two criteria will be verified by the investigators during an initial site visit. Wells satisfying all four criteria will be scheduled for data collection.

5.2 Water Level Measurement Procedures

The WRIA 53 Groundwater Level Monitoring Program will follow the field groundwater measurement procedures as outlined in the USGS Quality Assurance Plan for Groundwater Activities (2005). A copy of the specific field procedures as outlined in this document is included in Section 12.

Section 6
Quality Control

In addition to the standardized procedures described in Section 6, the following additional steps will be taken to ensure an adequate level of quality control during sampling.

- Accurate field notes will be maintained that describe field procedures, record values for measured field parameters, track sample identification, and note any variation from the planned procedure.
- Field instruments will be calibrated and/or checked in accordance with the manufacturer's instructions on a daily basis at the beginning of each sampling day, and as needed during the day.
- All non-dedicated, non-disposable field equipment coming into contact with sample water will be cleaned between uses at subsequent sampling locations to prevent cross-contamination of samples.

Section 7
Data Management Procedures

Field data will be recorded by field personnel at the time of measurement or sampling in a field notebook (log). Data to be entered into field notebooks include names of field personnel, station identification, dates and times of measurement or sampling, appropriate field measurement values and units of measure, and detailed notes on any deviations from prescribed procedures.

The documentation for each sampling location will include the completed field notebook (log) entry. Full documentation for all field monitoring activities will be compiled and stored at the principal investigator's office, and at the LCCD office.

Data will be entered into an electronic database hosted by the principal investigator. The database will be developed and approved by the WRIA 53 Planning Unit. Stored data will be made available to Ecology on request and at the completion of the project.

Section 8
Audits and Reports

The Lincoln County Planning Department will submit monthly project status reports to Ecology summarizing the sampling activities completed during the previous month. These monthly reports may be included in the standard quarterly grant progress reports submitted to Ecology.

A final report will be prepared that will include tabulations of all the water level data, a discussion of the data quality and usability, and a summary of data analysis and interpretations in support of the WRIA 53 Groundwater Level Monitoring Project.

Section 9
Data Review, Verification, and Validation

All data collected is subject to review by the principal investigator to determine if the data meets QAPP objectives. Decisions to reject or qualify data will be made by the principal investigator in conjunction with the other investigators. Data may be rejected because of inadequate or deficient documentation or because the QC sample results fail to meet the MQOs identified in Section 4.

9.1 Data Review and Verification

Field personnel will review data recorded in field notebooks for correctness, clarity and completeness at the end of each sampling activity. All field hydrogeologic data will be reviewed and supervised by a licensed hydrogeologist in the State of Washington.

The principal investigator will be responsible for reviewing water level data spreadsheets for transcription errors and completeness. The principal investigator will make the changes and notify all users. Anomalous data well will be flagged for investigation. If the principal investigator cannot reconcile the various interpretations, anomalous data from a particular well will not be included in the final database (although a paper copy of the well record and its possible interpretation will be in the project files.) The principal investigator also will review QA results for completeness and adherence to the data quality objectives identified in Section 4.0. If the quality objectives are not being met, the principal investigator will isolate the cause of the problem and take appropriate action with respect to the future use of the suspect data.

9.2 Data Validation

Upon receipt of the verified data, the principal investigator will determine if the results meet the MQOs for bias, precision, and accuracy for that sampling episode.

Precision will be estimated by calculating the relative percent difference (RPD) between results for duplicate pairs. These values provide an indication of the degree of random variability introduced by sampling and analytical procedures.

Section 10
Data Quality (Usability) Assessment

The purpose of the water level collected during this project is to determine basic aquifer groundwater level properties. The data will be used to provide input to developing a refined conceptual groundwater model, and be utilized for future water resource management and planning efforts in WRIA 53. If measurement quality objectives are met for all sampling episodes, the data will be considered acceptable for use except as qualified during the data review and validation process, and no additional data quality assessment will be needed.

Section 11
References

U.S. Geological Survey Techniques of Water Resources Investigations
Book 3: Ground-Water Techniques; Book 8: Instrumentation

Drost, B.W., 2005, Quality-assurance plan for ground-water activities, U.S. Geological Survey, Washington Water Science Center: U.S. Geological Survey Open-File Report 2005-1126, 27 p.

SECTION 12

GROUNDWATER FIELD PROCEDURES (From USGS Quality-Assurance Plan for Groundwater Activities, OFR 2005-1126)

12.1 Groundwater Site Inventory

To specify procedures for well and spring site inventory (location) and the minimum amount of information that should be collected during the initial reconnaissance of an individual ground-water site.

Materials and Instruments

1. A state highway map, county road map, a USGS 7.5-minute topographic quadrangle map, and a quarter-quarter section grid overlay. When required, an aerial photograph, or a town plat/lot number map also may be used. A Global Positioning System (GPS) instrument should be used to establish an accurate well location.
2. Well schedule form 9-1904-A (http://wwwnwis.er.usgs.gov/forms/GW-site-form.pdf) and water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf), or other forms approved by the WWSC Ground-Water Specialist.
3. Orienteering (transparent base) compass (optional).
4. Equipment for water-level measurements.
5. Pen or pencil.
6. Camera and film and whiteboard and marker (optional).
7. Washington Department of Ecology (WDOE) Water Well Report or other documents pertaining to the well being inventoried (optional).

Data Accuracy and Limitations

1. Latitude and longitude values determined using a GPS instrument can be read to the nearest tenth of a second and generally are accurate to at least one-half second.
2. Well construction information obtained from the well driller or from geophysical logs generally should be considered as more reliable than information obtained verbally from the well owner.
3. Altitudes determined from topographic maps are considered to be accurate to within one-half of the map contour interval.

Assumptions

1. A ground-water site is a single point, not a geographic area or property.
2. A GPS instrument is used to determine the latitude and longitude.
3. A USGS 7.5-minute topographic quadrangle map with 1:24,000-scale will be used to plot the well location and determine land-surface altitude. The person locating the well can accurately plot the location on the 7.5-minute topographic quadrangle map.
4. Site information is recorded on form 9-1904-A or other forms approved by the WWSC Ground-Water Specialist, as it is collected and never documented from memory.
5. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

Note: The minimum data requirements for GWSI change frequently as the software is updated. Consult GWSI Database Administrator for updates to minimum requirements.

1. By examining available data files and interviewing the well owner and (or) driller, compile the following ground-water site data in the field using form 9-1904-A or other forms approved by the WWSC Ground-Water Specialist.

Note: It is critical to determine that the well visited is indeed a match for the driller's log or other data taken into the field (i.e., use the WDOE well tag number, the log data [e.g., casing type and diameter, well depth, date drilled, owner's name, site address, etc.], reported information, and your observations to establish a reasonable certainty that there is a match).

a) Source of information—Date of site visit and name of person conducting site visit.

Note: All field-recorded information should come from observation/measurement or be reported by owner, renter, neighbor, etc. Information from the driller's log should NOT be copied to the field form.

b) Geographic location.

c) Political regimes—State and county or town identification and land-net location.

d) Source identifiers—Owner's name and address.

e) Individual site characteristics—Topographic setting, use of site, use of water.

f) Well construction—Driller's name, date drilled, type of well (drilled, bored, or dug), total depth, casing (type, depth, and diameter), finish (screen, open hole). It is important to note which data are from observations and which are reported (e.g., was well depth measured or reported?).

g) Any reported information on well yield, dependability, amount of water use, water quality, or any other pertinent items should be recorded on the field well schedule (C185).

h) WDOE "Unique Well No.": If a WDOE tag is present, the number should be recorded on the field schedule (C190). This number should be compared to the number on the driller's log to verify a match between the log and well being visited.

Note: Some well drillers attach information on well depth, casing depth, water levels, etc., to the well casing (or in concrete pads around wells, etc.). Also, some well owners record information (water levels, water usage, etc.) on walls of well houses. This type of information should be recorded on the field schedule (C185) and the source of the information indicated.

2. Locate and plot the ground-water site.

3. Prepare a detailed sketch map of the site location.

4. Record water-level measurements and date and time measured on water-level measurement field form 9-194 or other forms approved by the WWSC Ground-Water Specialist. See technical procedure documents for making water-level measurements using a graduated steel tape (Section 12.4), an electric sounding tape (Section 12.5), or an air line (Section 12.6). See (Section 12.7) for making water-level measurements in a flowing well.

5. OPTIONAL—Take photographs of the well location (indicating on the photograph the direction of view) and the measuring point (MP). Include in the photograph a whiteboard with the well number or other identifying information indicated. File photographs with the other site data.

Data Recording

Data are recorded in the field on well schedule form 9-1904-A or other forms approved by the WWSC Ground-Water Specialist. Water levels are recorded on the water-level measurements form 9-194 or other forms approved by the WWSC Ground-Water Specialist. All field forms, the sketch map, photographs, and a copy of the field topographic map showing the plotted location are to be filed together in the WWSC's permanent ground-water records.

Selected References

American Society for Testing and Materials, 1994, ASTM standards on ground water and vadose zone investigations (2d ed.): Philadelphia, Pa., American Society for Testing and Materials, p. 300-304.

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Handbook, chap. 2, p. 1-149.

U.S. Geological Survey, 1990, National water information system user's manual, ground-water site inventory system: U.S. Geological Survey Open-File Report 89-587, v. 2, chap. 4, (variously paged).

12.2 Locating a Well

To specify procedures for characterizing the location of a well.

Materials and Instruments

1. A Global Positioning System (GPS) instrument.
2. A state highway map.
3. USGS 7.5-minute topographic quadrangle map, 1:24,000-scale and quarter-quarter section grid overlay.
4. Well schedule form 9-1904-A (http://wwwnwis.er.usgs.gov/forms/GW-site-form.pdf) and water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf), or other forms approved by the WWSC Ground-Water Specialist.
5. Pen or pencil.
6. Orienteering (transparent base) compass (optional).
7. Town or county plat map (optional).
8. Aerial photograph (optional).

Data Accuracy and Limitations

1. Latitude and longitude values determined using a GPS instrument can be read to the nearest tenth of a second and generally are accurate to at least one-half second.

Assumption

1. The person locating the well has been trained to use a GPS instrument to determine the latitude and longitude of a point on the ground.

Instructions

1. The GPS unit should be placed as close as possible to the well while also being positioned to allow the maximum number of satellites to be used (avoid interference from metal buildings, power lines, etc.). The position of the GPS unit relative to the well should be recorded (e.g., 40 ft southwest of well – to avoid metal well house) (adjustments to the recorded latitude/longitude should be made to account for the positioning of the GPS instrument). After the GPS instrument has obtained a steady reading, record the latitude, longitude, number of satellites, estimated position error, and datum used. Latitude and longitude should be recorded in degrees, minutes, and seconds. The GPS instrument model and identification number should be recorded.

   Note: When visiting a well that has a latitude/longitude determined from a previous single GPS measurement, repeat the GPS measurement and compare to the previous values.

   2. Prepare a detailed sketch map of the site location. The sketch map should include a North arrow. The sketch map should contain enough detail so that a person who has never visited the site can find the well again. Include distances (in feet) from permanent landmarks, such as buildings, bridges, culverts, and road center lines. These distances should be measured by pacing where possible (if distances are estimated, so indicate). Distances from road intersections may be measured using a vehicle odometer and recorded to the nearest 0.1 mi. The "topographic setting" should be noted and recorded (see C19 of form 9-1904-A). In addition, detailed sketches of the well including the measuring point (MP), access ports for water-level measurements, and sampling points should be drawn on the back of the field form with the date recorded. This information is updated during each future site visit.

   3. The ground-water site should be plotted on the topographic map while at the site. The sketch map and topographic map plot should be compared for consistency while in the field.

   4. In the office, the latitude and longitude determined with the GPS instrument should be used to plot (digitally) the well locations as accurately as possible on a 7.5-minute topographic map. The land-surface altitude should then be determined from this plotted location and coded into GWSI. The digital plot should be compared to the field topographic map plot. The local site number (Township/Range-Section-Quarter-Quarter Section) generated from the field plot should be checked versus the digital plot and reassigned if necessary. If available, use LIDAR data to determine a more accurate land-surface altitude than is possible from the topographic map.

   5. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Data Recording

Data are recorded in the field on well schedule form 9-1904-A or other forms approved by the WWSC Ground-Water Specialist. All field forms, the sketch map, and a copy of the field topographic map showing the plotted location are to be filed with the WWSC's permanent ground-water records.

Selected References

American Society for Testing and Materials, 1994, ASTM standards on ground water and vadose zone investigations (2d ed.): Philadelphia, Pa., American Society for Testing and Materials, p. 300-304.

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Handbook, chap. 2, p. 1-149.

U.S. Geological Survey, 1990, National water information system user's manual, ground-water site inventory system: U.S. Geological Survey Open-File Report 89-587, v. 2, chap. 4, (variously paged).

12.3 Well Depth Measurement Using a Graduated Steel Tape

To measure the total depth of a well below land-surface datum using a graduated steel tape. This method is recommended for wells less than 200-ft deep.

Materials and Instruments

1. Steel tape graduated in feet, tenths and hundredths of feet. A break-away weight should be attached to the end of the tape, strongly enough to hold the weight, but not as strong as the tape, so that if the weight becomes lodged in the well the tape still can be pulled free. The weight should be brass, stainless steel, or iron.
2. Clean rag.
3. Diluted household chlorine bleach (20:1 dilution with tap water), single-use towels, and latex gloves (optional).
4. Tool box.
5. Pen or pencil.
6. Water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf) or other forms approved by WWSC Ground-Water Specialist.
7. Gloves, of leather or other protective material (optional).

Data Accuracy and Limitations

1. A graduated steel tape commonly is accurate to 0.01 ft.
2. The steel tape should be calibrated against another acceptable steel tape. An acceptable steel tape is one that is maintained, in the office, for use only for calibrating steel tapes.
3. When measuring well depth in deep wells, tape expansion and stretch is an additional consideration (Garber and Koopman, 1968).
4. If the well casing is angled instead of vertical, the well depth will have to be corrected.

Advantages

1. The graduated steel tape is considered to be the most accurate method of measuring well depth.
2. Easy to use.
3. Small diameter allows entry to wells with openings too small for probes on electrical tapes.

Disadvantages

1. Not recommended for measuring wells with installed pumps (definitely not in pumping wells).
2. Difficult to get accurate results for wells in excess of 200-ft deep.

Assumptions

1. An established measuring point (MP) exists.
2. The MP is clearly described so that a person who has not measured the well will know where to measure from.
3. The well is free of obstructions. Well obstructions, if present, could cause errors in the measurement if the obstructions affect the plumbness of the steel tape.
4. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

1. Before making the well-depth measurement in a well used for drinking-water supply, disinfect the weights and that portion of the tape that will pass below the water level in the well with dilute bleach solution.

Note: Preferred method of disinfection is to submerge the end of the tape and weights in the bleach solution (5-gal plastic containers with small diameter screw-on caps are included for this purpose with the WWSC ground-water field equipment). However, generally only the first 5–10 ft of the tape can be disinfected by submergence. The remainder can be disinfected by running the tape over a clean cloth soaked in the bleach solution as the tape is lowered into the well.

Note: Latex gloves are recommended for this procedure (to increase sanitary condition of tape as well as to protect the individual from bleach solution). When possible, the recommended procedure is to use the latex gloves for both the disinfecting procedure and the measurement itself (this may not be possible when measuring deep water levels—leather gloves may be required to avoid cutting your hand with the edge of the

tape).

2. Measure from the zero point on the tape to the bottom of the weight. Record this number as the length of the weight interval.

3. Lower the weight and tape into the well until the weight reaches the bottom of the well and the tape slackens. The tape should be lowered by sliding it over the palm of one hand, which is held as directly above the well as possible while the other hand holds the handle of the tape reel and swings it in a pendulum motion (allowing the weight of the tape to be felt continuously, thereby reducing the chance of the tape hanging up and becoming tangled).

Note: Gloves are recommended for this procedure.

4. Partially withdraw the tape from the well until the weight is standing in a vertical position, but still touching the bottom of the well. A slight jerking motion will be felt as the weight moves from the horizontal to the vertical position.

5. Repeat step 3 several times by lowering and withdrawing the tape to obtain a consistent reading.

6. Record the tape reading held at the MP.

7. Withdraw the tape from the well 1–2 ft, so that the weight will hang freely above the bottom of the well. Repeat steps 2 through 4 until two consistent depth readings are obtained.

8. Calculate total well depth below land-surface datum (LSD) as follows:

(Tape reading held at the MP) + (Length of the weight interval) +/– (MP correction) =

Total well depth below LSD.

Data Recording

Data are recorded in the field on water-level measurement form 9-194 or other forms approved by the WWSC Ground-Water Specialist. The original field form is to be filed with the WWSC's permanent ground-water records. Well-depth data also should be recorded in the ground-water site data section, on the second page of the GWSI ground-water site schedule (form 9-1904-A). All data are recorded to the nearest 0.01 ft.

Selected References

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

U.S. Geological Survey, 1989, Yucca Mountain Project—Use of hand-held steel tapes in vertical boreholes, U.S. Geological Survey Technical Procedure HP-61, p. 2.

12.4 Water Level Measurements Using a Graduated Tape

To measure the depth to water surface below a measuring point using the graduated steel tape (wetted-tape) method.

Materials and Instruments

1. A steel tape graduated in feet, tenths and hundredths of feet. A break-away weight should be attached to the end of the tape, strong enough to hold the weight, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free. The weight should be brass, stainless steel, or iron. The most commonly used weights in the Washington WWSC are "sausage weights" (alternating several-inch long segments of surgical tubing and stainless steel or brass rods). It is permissible to use an unweighted tape where conditions do not allow access for a weighted tape – in these circumstances; the tape should be carefully inspected to make sure it is free of any kinks or bends that would decrease the accuracy of the measurement.
2. Blue carpenters chalk.
3. Clean rag.
4. Pen or pencil.
5. Water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf) or other forms approved by WWSC Ground-Water Specialist.
6. Tool box.
7. Diluted household chlorine bleach (20:1 dilution with tap water), single-use towels, and latex gloves (optional).
8. Gloves, of leather or other protective material (optional).

Data Accuracy and Limitations

1. A graduated steel tape is commonly accurate to 0.01 ft.
2. The steel tape should be calibrated against another acceptable steel tape. An acceptable steel tape is one that is maintained, in the office, for use only for calibrating steel tapes.
3. When measuring deep water levels, tape expansion and stretch is an additional consideration (Garber and Koopman, 1968).

Advantages

1. The graduated steel tape method is considered to be the most accurate methods for measuring the water level in nonflowing wells of moderate depth.
2. Easy to use.

Disadvantages

1. May be impossible to get reliable results if water is dripping or cascading into the well or condensing on the well casing. Cascading water is common in open-hole basalt wells in eastern Washington.
2. Potentially hazardous (to pumps and people) in pumping wells. Pumping levels should be measured only if there is reliable information as to the intake depth of the pump (tapes should not be lowered to any closer than 5 ft of the intake depth).
3. Difficult to get reliable results if an oil layer is present.
4. Because there is generally no indication of when the water level has been reached, it is possible to lower the tape into the water past the point to which the tape has been disinfected.

Assumptions

1. An established measuring point (MP) exists or will be established as part of measurement.
2. The MP is clearly described so that a person who has not measured the well will know where to measure from.
3. A water-level measurement taken during the last field visit or from the driller's log is available to estimate the length of tape that should be lowered into the well. If no previous measurement information is available, first measurement may be done more efficiently by using an electric sounding tape.
4. The well is free of obstructions. Well obstructions, if present, could cause errors in the measurement if the obstructions affect the plumbness of the steel tape.
5. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

1. Before making the water-level measurement in a well used for drinking-water supply, disinfect with diluted bleach solution and dry with single-use towels (e.g., techwipes) the first 5 to 10 ft of the tape, including weights.

   Note: Preferred method of disinfection is to submerge the end of the tape and weights in the bleach solution (5-gal plastic containers with small diameter screw-on caps are included for this purpose with the WWSC ground-water field equipment).

   Note: Latex gloves are recommended for this procedure (to increase sanitary condition of tape as well as to protect the individual from bleach solution). When possible, the recommended procedure is to use the latex gloves for both the disinfecting procedure and the measurement itself (this may not be possible when measuring deep water levels—leather gloves may be required to avoid cutting your hand with the edge of the tape).

2. Chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk. The wetted chalk mark will identify that part of the tape that was submerged.

3. Lower the tape and weight into the well until the lower end of the tape is submerged below the water. The tape should be lowered by sliding it over the palm of one hand which is held as directly above the well as possible while the other hand holds the handle of the tape reel and swings it in a pendulum motion (allowing the weight of the tape to be felt continuously, thereby reducing the chance that the tape will hang up and become tangled). Slowly lower the tape and weight into the water to prevent splashing. Continue to lower the end of the tape into the well until the tape has reached several feet past the assumed water-level depth. Hold the tape against the MP and record the value on the tape in the `MP HOLD' column of the water-level measurements field form 9-1905-A or other form approved by the WWSC Ground-Water Specialist.

   Note: Gloves are recommended for this procedure.

4. Rapidly bring the tape to the surface before the wetted chalk mark dries and becomes difficult to read. Record the number of the wetted chalk mark (referred to as the cut) in the `WETTED CHALK MARK' column of the water-level measurements field form, 9-1905-A or other forms approved by the WWSC Ground-Water Specialist.

   Note: In extremely cold conditions, freezing of the water on the tape sometimes distorts the wetted chalk mark and may also make drying and rechalking the tape very difficult. If so, use an electric sounding tape.

5. Subtract the wetted chalk mark number from the number held to the MP, and record this number in the `DEPTH TO WATER FROM MP' column of the water-level measurements field form, 9-1905-A or other forms approved by the WWSC Ground-Water Specialist. The difference between these two readings is the depth to water below the MP. Record depth to water, date and time of measurement, and initials of party making the measurement.

6. Apply the MP correction to get the depth to water below or above land-surface datum. If the MP is above land surface, the distance between the MP and land-surface datum is subtracted from the depth to water from the MP to obtain the depth to water below land surface. If the MP is below land surface, precede the MP correction value with a minus (−) sign and subtract the distance between the MP and land surface datum from the depth to water from the MP to obtain the depth to water below land surface (this is the same as adding the MP to the depth of water below the MP). Record this number in the `DEPTH TO WATER FROM LSD' column of the water-level measurements field form, 9-1905-A or other forms approved by the WWSC Ground-Water Specialist. If the water level is above LSD, record the depth to water in feet above land surface as a negative number.

7. Make a check measurement by repeating steps 1 through 5. The check measurement should be made using a different hold value than that used for the original measurement. The difference between hold values should not be an integer number of feet. For example, if the first hold is 91.00 ft, then the second should not be 92.00 ft, but could be 92.20 ft. If the check measurement does not agree with the original measurement within 0.02 ft, continue to make check measurements until the reason for the lack of agreement is determined or until the results are shown to be reliable. If more than two readings are taken, record the average of all readings (exception: if several readings agree within 0.02 ft, while another differs by more 0.02 ft, then the outlier can be ignored. It is common in wells with pump columns, wiring, etc. down the hole to have the tape travel in a multitude of pathways as it is lowered into the well; this sometimes results in what appear to be valid measurements, but which cannot be easily repeated. If repeated measurements indicate a non-static condition

(e.g., the water level is rising due to recovery from recent pumping, or the water level is declining due to pumping of a nearby well), indicate the appropriate status of the water level on the field form. To determine if the water level measured is truly static, repeat measurements should be at least 3 minutes apart. Wells in Washington commonly have slowly rising or declining water levels, which differ greatly from static conditions. If only non-static water levels are recorded, then the highest level should be coded into GWSI.

8. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks and possible stretch due to the suspended weight of the tape and the tape weight.
9. In some pumped wells (typically those with turbine pumps), a layer of oil may float on the water surface. If the oil layer is thin (generally a foot thick or less), read the tape at the top of the oil mark and use this data for the water-level measurement instead of the wetted chalk mark. The measurement will differ slightly from the water level that would be indicated were the oil not present. However, if more than a foot of oil is present in the well, or if it is necessary to know the thickness of the oil layer, a commercially available water-detector paste can be used that will detect the presence of water in the oil. The paste is applied to the lower end of the tape and will show the top of the oil as a wet line, and the top of the water will show as a distinct color change. Because oil density is about three-quarters that of water, the water level can be estimated by adding the thickness of the oil layer times its density to the oil-water interface elevation. The status of the water level should be recorded as "V" (foreign substance) and noted in remarks.

Data Recording

All water-level data are recorded on the water-level measurement form 9-194 or other forms approved by the WWSC Ground-Water Specialist, to the nearest 0.01 ft. All original field forms are filed with the well records.

Selected References

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Handbook, chap. 2, p. 1-149.

12.5 Water Level Measurements Using an Electric Sounding Tape

To measure the depth to the water surface below a measuring point using the electric-tape method.

Materials and Instruments

1. Electric water-level measurement device. Electric sounding tapes commonly are mounted on a hand-cranked supply reel that contains space for batteries and some device for signaling when the circuit is closed. To be acceptable, electric sounding tapes must be stretch-resistant and graduated in 0.01-ft intervals.

   Note: "old-style" electric sounding tapes graduated in 5-ft intervals and (or) without embedded stretch-resistant cables, should no longer be used in the WWSC.

2. Pen or pencil.
3. Water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf) or other forms approved by the WWSC Ground-Water Specialist.
4. Tool box (see Ground-Water Tool Box; recommended contents).
5. Diluted household chlorine bleach (20:1 dilution with tap water), single-use towels, and latex gloves (optional).
6. Gloves, of leather or other protective material (optional).

Data Accuracy and Limitations

1. Independent electric sounding tape measurements of static water levels using the same tape should agree within + or - 0.02 ft for depths of less than about 250 ft.
2. For depths in excess of 250 ft, the maximum difference of independent measurements using the same tape should agree within ±0.04 ft.
3. For depths in excess of about 1,000 ft, the repeatability of measurements using the same tape should agree within ±0.1 ft.

Advantages

1. Superior to steel tape method when water is dripping or cascading into the well or condensing on the inside casing walls, which may make it impossible to get a good water mark on a chalked steel tape.
2. Superior to steel tape method in wells that are being pumped, particularly with large-discharge pumps, where the splashing of the water surface makes consistent results by the wetted-tape method impossible.
3. Superior to steel tape method when a series of measurements are needed in quick succession, such as during aquifer tests, because the electric sounding tape does not have to be removed from the well for each reading.
4. Superior to steel tape when making measurements in the rain.
5. Safer to use in pumping wells than steel tape method because the water is sensed as soon as the probe reaches the water surface and there is less danger of lowering the tape into the pump impellers.
6. May be easier to use for deep water levels or in cramped conditions due to lighter weight.
7. Much easier and faster water-level measurements than with steel tape method, particularly when no estimate of the water level is available before measurement is made.
8. Much less likely to extend tape into water past the point to which the tape has been disinfected.

Disadvantages

1. Harder to keep calibrated than a steel tape. Electric connections need to be maintained in good order.
2. Probes are of greater diameter than steel tapes and therefore will not fit into some well openings accessible to steel tapes.

Assumptions

1. An established measuring point (MP) exists or will be established as part of the measurement.
2. The MP is clearly described so that a person who has not measured the well will know where to measure from.
3. The well is free of obstructions. Well obstructions, if present, could cause errors in the measurement if the obstructions affect the plumbness of the electric sounding tape.
4. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

1. Before making the water-level measurement in a well used for drinking-water supply, disinfect with diluted bleach solution and dry with single-use towels (e.g., chemwipes) the first 5–10 ft of the tape, including weights.

   Note: Preferred method of disinfection is to submerge the end of the tape and weights in the bleach solution (5-gal plastic containers with small diameter screw-on caps are included for this purpose with the WWSC ground-water field equipment: use 1-qt household bleach and tap water to fill 5-gal container). **Note:** Latex gloves are recommended for this procedure (to increase sanitary condition of tape as well as to protect individual from bleach solution). When possible, the recommended procedure is to use the latex gloves for both the disinfecting procedure and the measurement itself (this may not be possible when measuring deep water levels—leather gloves may be required to avoid blistering your hand from the friction of the tape passing over it).

2. Check the circuitry of the electric sounding tape before lowering the probe into the well, either by turning the control to test mode, or placing the probe in water.

   Note: Most newer tapes have a sensitivity setting. Start with the setting in mid-range and adjust as necessary.

3. Lower the tape (and weight, if needed) into the well. The tape should be lowered by sliding it over the palm of one hand which is held as directly above the well as possible while the other hand holds the handle of the tape reel and swings it in a pendulum motion (allowing the weight of the tape to be felt continuously, thereby reducing the chance of the tape hanging up and becoming tangled). The tape and weight should be lowered slowly into the water to prevent splashing. Continue to lower the end of the tape into the well until contact with the water surface closes the circuit activating the indicator (light, buzzer, etc.). The tape should be raised and lowered a few inches at a time to best locate the point where the indicator is activated. Hold the tape against the MP and record the value on the tape in the `MP HOLD' column of the water-level measurements field form 9-1905-A or other forms approved by the WWSC Ground-Water Specialist.

   Note: Gloves are recommended for this procedure.

4. Apply the MP correction to get the depth to water below or above land-surface datum. If the MP is above land surface, the distance between the MP and land surface datum is subtracted from the depth to water from the MP to obtain the depth to water below land surface. If the MP is below land surface precede the MP correction value with a minus (−) sign and subtract the distance between the MP and land surface datum from the depth to water from the MP to obtain the depth to water below land surface (this is the same as adding the MP to the depth of water below the MP). Record this number in the `DEPTH TO WATER FROM LSD' column of the water-level measurements field form, 9-1905-A or other forms approved by the WWSC Ground-Water Specialist. If the water level is above LSD, record the depth to water in feet above land surface as a negative number.

5. Make a check measurement by repeating steps 2 and 3. If the check measurement does not agree with the original measurement within the accuracy given under data accuracy, continue to make check measurements until the reason for the lack of agreement is determined or until the results are shown to be reliable. If repeated measurements indicate a non-static condition (e.g., the water level is rising due to recovery from recent pumping, or the water level is declining due to pumping of a nearby well), indicate the appropriate status of the water level on the field form. Repeat measurements should be at least 3 minutes apart (in order to determine if the water level measured is truly static—wells in Washington commonly have slowly rising or declining water levels, which differ greatly from static conditions).

   Note: Record the identification number of the electric sounding tape on the field form.

6. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks, and possible stretch due to the suspended weight of the tape and the tape weight. Do not let the tape rub across the top of the casing because the insulating sheathing could be breached, resulting in shorting of the circuit.

   Note: At least once during each field trip (minimum of once a week during prolonged trips), measure a water level using both an electric sounding tape and a steel tape. These check measurements should be reported to the WWSC Ground-Water Specialist for inclusion in an electrical tape versus steel tape comparison file.

Data Recording

All data are recorded on the water-level measurement form 9-194 or other forms approved by the WWSC Ground-Water Specialist, to the appropriate accuracy for the depth being measured. See data accuracy and limitations. All original field forms are filed with the well records.

Selected References

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water Supply Paper 2220, p. 72-73.

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Handbook, chap. 2, p. 1-149.

12.6 Water Level Measurements Using and Existing Air Line

To measure the depth to the water surface below a measuring point using the submerged air line method in an existing air line. Use this method only if wetted-steel tape or electric sounding tape methods are not applicable (e.g., no access for tape).

Materials and Instruments

1. Calibrated pressure gage with tee connector (one end with a tire valve stem [to connect to bicycle pump or air tank regulator] and one end with tire valve stem connector [to connect to air line]).
2. Bicycle pump or compressed air tank with regulator.
3. Pen or pencil.
4. Water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf) or other forms approved by the WWSC Ground-Water Specialist.

Data Accuracy and Limitations

1. Water-level measurements using an existing air line should be accurate to 1 ft.
2. When measuring deep water levels, corrections for fluid temperatures and vertical differences in air density are additional considerations (Garber and Koopman, 1968).

Advantages

1. Especially useful in pumped wells where water turbulence may preclude using a more precise method.
2. Method can be used while the well is being pumped, when splashing of water makes accurate measurements with the wetted steel tape method impossible.
3. In many eastern Washington wells, existing air lines (owner- or driller-installed) are the only means of measuring water levels. Either no other access into the well casing is available, or other conditions, such as high rates of cascading water, render other methods ineffective.

Disadvantages

1. Less accurate than the wetted steel tape or the electric sounding tape methods.
2. Requires information on the air-line length (accuracy of this reported information generally is unknown).

Assumptions

1. An established measuring point (MP) exists.
2. The MP is clearly described so that a person who has not measured the well will know where to measure from.
3. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

1. Attach pressure gage to air line (use tire valve stem connector end of tee connector).
2. Attach bicycle pump or regulator from air tank to tire valve end of tee connector.
3. Expel all water from air line by forcing compressed air into the air line using bicycle pump or air tank. A maximum pressure reading will be attained when all water is expelled (at this point, continued pumping or induction of compressed air from the air tank does not induce an increased pressure reading). Record the pressure reading (psi). If possible, use a pressure gage for which the reading will fall within the middle one-third of the gage's range (for best accuracy).
4. Multiply the pressure reading (psi) times 2.31 (ft/psi) to determine the length of the water column that was expelled from the air line.
5. Subtract the length of the water column expelled from the depth of the bottom of the air line to obtain the depth to water below the MP.
6. Apply the MP correction to get the depth to water below land-surface datum.
7. Record the water-level data on field form to an accuracy of 1 ft.

Data Recording

All data are recorded on the water-level measurement form 9-194 or other forms approved by the WWSC Ground-Water Specialist. All original filed forms are filed with the well records.

Selected References

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

Johnson, E.E., 1975, Ground water and wells—A reference book for the water-well industry (1st ed., 4th printing): Saint Paul, Minn, Johnson Division, Universal Oil Products, Inc., p. 90-91.

Loman, S.W., 1953, Measurement of ground-water levels by air-line method: U.S. Geological Survey Open-File Report 53-159, 5 p.

12.7 Water Level Measurements in a Flowing Well

To measure low-pressure or high-pressure water-level heads in flowing wells.

Materials and Instruments

1. Low-pressure head measurement.
   a) Short length of transparent plastic tubing.
   b) Hose clamps.
   c) Measuring scale (steel tape or pocket tape with 0.01-ft graduations).
2. High-pressure head measurement.
   a) Flexible hose with a 3-way valve.
   b) Hose clamps.
   c) Pressure gage.
   d) Tool box.
3. Pen or pencil.
4. Water-level measurement form 9-194 (http://wwwnwis.er.usgs.gov/forms/GW-wl-9-194.pdf) or other forms approved by the WWSC Ground-Water Specialist.

Data Accuracy and Limitations

1. With care and experience, low-pressure head measurements can be measured to an accuracy of 0.1 ft.
2. High-pressure head measurements using a pressure gage probably are accurate to about 0.5 ft (report to nearest 1 ft).
3. When a flowing well is closed or opened by a valve or test plug, it should be done gradually. If pressure is applied or released suddenly, the well could be permanently damaged by the "water-hammer effect" by caving of the aquifer material, breakage of the well casing, or damage to the distribution lines or gages.
4. Ideally, all flow from the well should be shut down so a static water level can be measured. However, because of well owner objections or system leaks, this is not always possible. If the leak is very small relative to the pressure reading, the water level can be recorded with an indicated status of "other" (this should be explained in the field notes and in the "water-level status," C238, and "remarks," C150, elements in GWSI).
5. If a well has to be shut down, the time required to reach static pressure may range from hours to days. Because it may be impractical or impossible to reach true static conditions, record the shut-in time (amount of time since well stopped flowing or being pumped) for each gage reading and record water-level status as "E" (recently flowing). During return visits to a particular well, it is best to duplicate the previously used shut-in time before making a pressure gage reading.

Advantages

1. Low-pressure head measurements: Relatively simple and fast to perform and more accurate than high-pressure head measurements.

2. High-pressure head measurements: Can be used with water levels that are sufficiently above land surface to preclude easy low-pressure head method.

Disadvantages

1. Low-pressure head measurements: Generally impractical for water levels more than 5 or 6 ft above ground level.

2. High-pressure head measurements: Can be less accurate than low-pressure method. Pressure gages can be subject to erroneous readings if not properly handled and calibrated.

Assumptions

1. An established measuring point (MP) exists.

2. Pressure gages have been calibrated.

3. A logbook containing all calibration and maintenance records is available for each recording device.

4. All field notes should be neat, legible, and leave no doubt about interpretation. Errors/modifications should be indicated by a single line drawn through them (no erasures or blackouts).

Instructions

1. Low-pressure head measurement (direct measurement).

   a) Connect a short length of transparent plastic tubing tightly to the well with hose clamps (or other appropriate hardware, depending on individual well plumbing, etc.).

   b) Raise the free end of the tubing until the flow stops.

   c) Rest the end of the measuring scale (graduated in 0.01-ft increments) on the measuring point (MP), as level as possible.

   d) Read the water level directly, by placing the hose against the measuring scale.

   e) Apply the MP correction to get the depth to water above land-surface datum (LSD).

   f) Take a second reading at least 3 minutes after first reading.

   Note: The tubing should remain in the same upright position between measurements.

   g) To make sure that the well is not being used, check that there are no pressure fluctuations.

2. High-pressure head measurement (indirect measurement).

   a) Make sure that all well valves are closed except the one to the pressure gage. This should be done gradually to prevent water hammer effect. This will prevent use of the well during the measurement period and assure an accurate water-level reading. Record the original position of each valve that is closed (full open, half open, closed, etc.), so the well can be restored to its original operating condition.

   b) Connect a flexible hose with a 3-way valve to the well with hose clamps (or other appropriate hardware, depending on individual well plumbing, etc.).

   c) If possible, use a pressure gage for which the reading will fall within the middle one-third of the gage's range (for best accuracy).

   d) Attach the pressure gage to one of the two "open" valve positions using a wrench. Never tighten or loosen the gage by twisting the case because the strain will disturb the calibration and give erroneous readings.

   e) Bleed air from the hose, using the other "open" valve position.

   f) Open the pressure gage valve slowly to reduce the risk of damage by the water-hammer effect to the well, distribution lines and gages. Once the needle stops moving, tap the glass face lightly to make sure the needle is not stuck.

   g) To make sure that the well is not being used, check that there are no pressure fluctuations.

   h) If using a flexible hose with 3-way valve, hold the pressure gage in a vertical position with the center of the gage at the exact height of the MP. If an alternative method is used to attach the pressure gage to the well, a new MP may need to be used (and documented). Read the pressure gage to the smallest increment (of pounds per square inch) possible and multiply this value by 2.31 to convert to feet (report value to nearest 1 ft).

   i) Apply the MP correction to get the depth to water above LSD.

   j) Take a second reading at least 3 minutes after the first reading.

   k) Record the identification number of the altitude/pressure gage with each water-level measurement so that the reading can be back referenced to the calibration record, if necessary.

Data Recording

All calibration and maintenance data for the gage are recorded in the logbook. All water-level data are recorded on the water-level measurement form 9-194 or other forms approved by the WWSC Ground-Water Specialist.

Note: The identification number of the pressure gage should be recorded on the field form.

Selected References:

U.S. Geological Survey, 1977, National handbook of recommended methods for water-data acquisition: U.S. Geological Survey Handbook, chap. 2, p. 1-149.