

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Manual Well-Depth and Depth-to-Water Measurements

Version 1.0

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*Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.*



## Environmental Assessment Program

Standard Operating Procedure for manually determining well depth and static depth-to-water (water-level) measurements in resource protection (monitoring) wells, upland piezometers, or water supply wells.

### **1.0 Purpose and Scope**

1.1 This document is the Environmental Assessment Program (EAP), Standard Operating Procedure (SOP) for manually measuring well depth and static depth-to-water (water level) using an electric-tape, steel-tape or existing air-line in resource protection (monitoring) wells, upland piezometers, or water supply wells. The procedure covers the collection of well site information, establishing a permanent measuring point from which to take the measurements, water level equipment maintenance and calibration, data collection and quality, and record management.

### **2.0 Applicability**

2.1 Depth-to-water measurements are used for a variety of purposes including constructing water table contour maps and hydrographs, determining groundwater flow directions and gradients, or defining seasonal water level fluctuations. The SOP does not cover the use of automated water-level monitoring devices such as pressure transducers.

### **3.0 Definitions**

3.1 Aquifer – A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield useful quantities of water to wells and springs.

3.2 Aquifer test – A test of the hydraulic properties of an aquifer. Aquifer testing involves repeated measurement of the hydraulic head response of an aquifer to the withdrawal or injection of a measured quantity of water from or to a well.

3.3 Cut – The term “cut” has two meanings depending on the water level measuring equipment being used. For an electric-tape, “cut” refers to the length of tape scale missing on a repaired tape. Depth-to-water measurements must be corrected for this missing portion of the scale. For a steel-tape, the term “cut” refers to the position on the tape scale where the wetted chalk/dry chalk mark identifies the distinct water boundary.

3.4 Data Logger/Pressure Transducer – Equipment installed in a well to allow continuous water level measurements. Continuous measurement of water levels can provide detailed information about aquifer head response to both short-term and long-term hydrologic events. A pressure transducer converts a pressure-induced mechanical change into an electrical signal. In a well, this pressure change can be caused by a

change in the height (and therefore the weight) of the water column over the pressure sensor.

- 3.5 DTW - Depth-to-Water, also referred to in this SOP as water level measurement.
- 3.6 EAP – Environmental Assessment Program
- 3.7 Ecology – Washington State Department of Ecology
- 3.8 EIM – Environmental Information Management System. A searchable database developed and maintained by the Washington State Department of Ecology.
- 3.9 Field Data Sheets – Weather resistant sheets (i.e. “Rite in the Rain” ® writing paper) used to document all field activities, sample data, methods and observations for each collection site.
- 3.10 Flame Ionization Detector/Photoionization Detector (FID/PID) – Detectors used to monitor the air space at the well head for wells that are suspected or known to be contaminated with volatile organics (i.e. petroleum products, dry cleaning solvents).
- 3.11 GPS - Global Positioning System
- 3.12 Hold – The marked location on the tape scale that is exactly opposite the measuring point (MP). The value on the tape scale represents the total length of tape lowered into a well during an individual water level measurement.
- 3.13 Land Surface Datum (LSD) – Selected land surface elevation at the well head. The LSD is used to convert depth-to-water data into groundwater elevations, which are in turn used to construct water table contour maps and hydrographs.
- 3.14 Measuring Point (MP) – An established point on a well casing from which depth-to-water/water level measurements are made. Well measuring points are established to ensure data comparability across time and workers.
- 3.15 Static Water Level – The level of water in a well that is not being affected by the withdrawal or injection of water.
- 3.16 Stickup – Measured height of the measuring point (MP) above or below the land surface. The stickup value is also referred to as the MP correction.
- 3.17 Top of Casing (TOC) – Top rim of the well casing or sanitary well seal. Measuring points are usually established on the top rim of the well casing.
- 3.18 Zero Point - On the electric tape this is the point on the probe’s sensor that first indicates contact with the water.

## **4.0 Personnel Qualifications/Responsibilities**

- 4.1 Personnel conducting field work must comply with the requirements of the EAP Safety Manual (Ecology, 2006). A working knowledge of the procedures in Chapter 1 ‘General Field Work’, and sections ‘Groundwater Sampling and Water-Level Measurements’ and ‘Hazardous Waste Sites’ in Chapter 2 is expected.

## **5.0 Equipment, Reagents, and Supplies**

### 5.1 Measuring Equipment

- 5.1.1 Electric-tape (water level meter)
- 5.1.2 Graduated Steel-tape with breakaway weight (brass, stainless steel or iron)
- 5.1.3 Chalk (carpenters)
- 5.1.4 Bicycle pump/or compressed air tank with regulator
- 5.1.5 Calibrated pressure gage
- 5.1.6 Steel hand measuring tape (engineer scale)
- 5.1.7 Permanent marking pen or paintstick ( for marking measuring point)
- 5.1.8 Field data sheets

### 5.2 Disinfecting Equipment

- 5.2.1 Deionized water
- 5.2.2 Laboratory grade soap (Liquinox®)
- 5.2.3 Dilute chlorine bleach solution
- 5.2.4 Cleaning solvents, if applicable
- 5.2.5 Nitrile or latex gloves

### 5.3 Safety Equipment

- 5.3.1 First aid kit
- 5.3.2 Orange vest, Ecology issued
- 5.3.3 Traffic cones
- 5.3.4 Traffic signs, if applicable
- 5.3.5 Air monitoring equipment [photoionization detector (PID) and/or flame ionization detector (FID)], if applicable

### 5.4 Miscellaneous Equipment

- 5.4.1 Pencils, pens, etc.
- 5.4.2 Calculator
- 5.4.3 Well location map
- 5.4.4 Well keys, if applicable
- 5.4.5 Compass
- 5.4.6 GPS unit
- 5.4.7 Digital camera
- 5.4.8 Paper towels or clean rags
- 5.4.9 Plastic garbage bags
- 5.4.10 Bucket, plastic 5-gallon
- 5.4.11 Field bag (containing rain gear, rubber boots, work gloves, etc.)

- 5.4.12 Hand cleaner
- 5.4.13 Product/Water interface probe, if applicable

## 5.5 Tools

- 5.5.1 Socket wrench set
- 5.5.2 Allen wrench set
- 5.5.3 Pipe wrenches
- 5.5.4 Crescent wrenches
- 5.5.5 Set of screwdrivers
- 5.5.6 File or knife
- 5.5.7 Hammer
- 5.5.8 Pliers
- 5.5.9 Hack saw
- 5.5.10 Crow bar/manhole hook
- 5.5.11 Shovel
- 5.5.12 Machete
- 5.5.13 Whiskbroom
- 5.5.14 Spare well cover bolts/nuts
- 5.5.15 Spare well caps/plugs
- 5.5.16 Spare pad locks/keys
- 5.5.17 Wire brush
- 5.5.18 WD-40
- 5.5.19 Bailing device (i.e. cooking baster, peristaltic pump with battery)
- 5.5.20 Flashlight
- 5.5.21 Spare batteries (i.e. electric-tape, GPS, flashlight)
- 5.5.22 Tape (duct tape/electrical tape)

## 6.0 **Summary of Procedure**

### 6.1 Well Site Information and Documentation

- 6.1.1 Prior to and during a well site visit detailed information should be collected for each well location to meet the data needs of Ecology's Environmental Information Management (EIM) system database. Refer to Section 7.0 for a list of the EIM data requirements. Data requirements for EIM change as the program is updated, therefore it should be checked at the start of a new project.
- 6.1.2 Record the geographic location of the well. This information can include a description and sketch map of the site location; map used to locate the well and the map scale; latitude-longitude or equivalent with level of accuracy; the vertical measurement or altitude, datum used and level of accuracy. Can also include the political region, i.e. state, county, town.
- 6.1.3 Individual well characteristics such as a well owner name and address, well tag number if applicable, well use and status, well construction information if available, and measuring point established or used. ***It is important to verify that any data taken into the field, such as a driller's log, matches the well being visited.***

- 6.1.4 If a well is selected for monitoring but was not previously tagged by the driller, the field team should tag the well during the initial well inventory. Well tags are available from Ecology's Water Resources Program. The tag should be securely attached to the well casing, or another permanent-easily-seen fixture of the water system. After tagging the well the field lead should complete a well tag form and submit it to Ecology's Water Resource Program along with the drillers log for the well.
- 6.2 Establish a Permanent Measuring Point (MP)
- 6.2.1 A permanent measuring point (MP) from which all depth-to-water/water levels will be measured must be established for each well to ensure data comparability. The MP should be established when a well is installed or when an existing well is inventoried.
- 6.2.2 Measuring points are normally established on the top rim of the actual well casing; this position is commonly referred to as 'Top of Casing' (TOC). Locate the MP at a convenient place from which to measure the water level.
- 6.2.3 Clearly mark the MP. The MP must be as permanent as possible and be clearly visible and easily located. The MP may be marked using a permanent black marker, bright colored paintstick, or with a notch filed into the TOC.
- 6.2.4 Describe the position of the MP clearly in the field data sheets. For measuring points that are difficult to see or locate, place a photo of the MP in the well file.
- 6.2.5 The MP height is established in reference to a land surface datum (LSD). The LSD is generally chosen to be approximately equivalent to the average altitude of the ground surface around the well.
- 6.2.6 Measure the height of the MP in feet relative to the LSD. MPs generally are established to the nearest 0.1 ft using a pocket tape to measure the distance from the MP to the LSD. Note that values for measuring points that lie below land surface should be preceded by a minus sign (-). Record the height of the MP and the date it was established.
- 6.2.7 Because MPs and the LSD may change over time, the distance between the two should be checked whenever there have been activities such as land development that could have affected either the MP or LSD at the site. Such changes must be measured as accurately as possible, documented and dated in field data sheets and in any database(s) into which the water level data are entered.
- 6.2.8 All subsequent water level measurements should be referenced to the established measuring point. The MP value will be used to convert your measurements into values that are relative to land surface.

- 6.3 Establish a Measuring Point (MP) on Aboveground Monitoring Wells
- 6.3.1 Check to see if a measuring point has already been established on the casing rim. If a clearly marked MP is already established and documented, use it.
- 6.3.2 Locate the MP at the most convenient place from which to measure the water level. MPs are commonly established on the north side of the casing rim or if the casing has been cut at a steep angle, at the lowest point of the casing rim.
- 6.3.3 Clearly mark the MP. The MP must be as permanent as possible and be clearly visible and easily located.

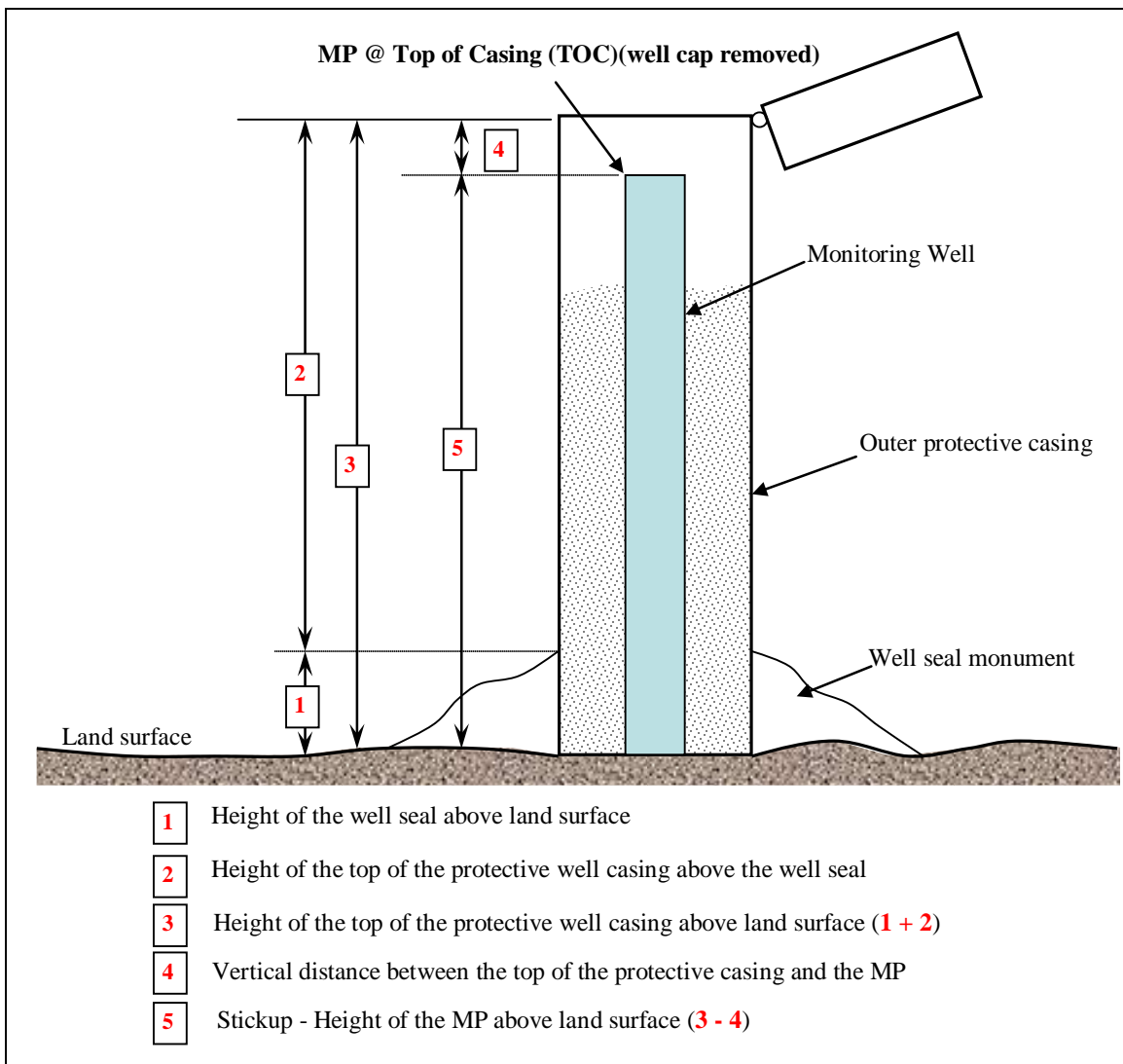


Figure 1. Determining the Measurement Point Height-Above-Land-Surface for an Aboveground Monitoring Well

- 6.3.4 Determine the MP vertical position in relation to the land surface (LSD) (Figure 1). If possible, use a leveling rod from the MP from which a measuring tape can hang freely to the land surface. Measure the height of the MP in feet above the LSD to the nearest 0.01 foot. Record this distance as a *positive (+)* value. If the ground surface is uneven, try to establish an ‘average’ position for the base of the tape. Some monitoring wells will also be surrounded by a sloping concrete well seal apron or monument; in this case, you may have to make a series of measurements and corrections to determine the final height of the MP above LSD (Figure 1).
- 6.3.5 Record information about the measuring point location in the field data sheets. Record the date the MP was established. If needed take a photo of the MP location.
- 6.4 Establish a Measuring Point (MP) on Flush-Mount Monitoring Wells
- 6.4.1 Establish a permanent MP on the casing rim. Clearly mark the MP.
- 6.4.2 Determine the MP in relation to the LSD using a measuring tape, to the nearest 0.01 foot. Assuming the top of the well casing is below land surface, record the distance as a *negative (-)* value. Figure 2 illustrates how to account for the height of the vault top plate above land surface if necessary.
- 6.4.3 Record the location and date of the MP in the field data sheets.

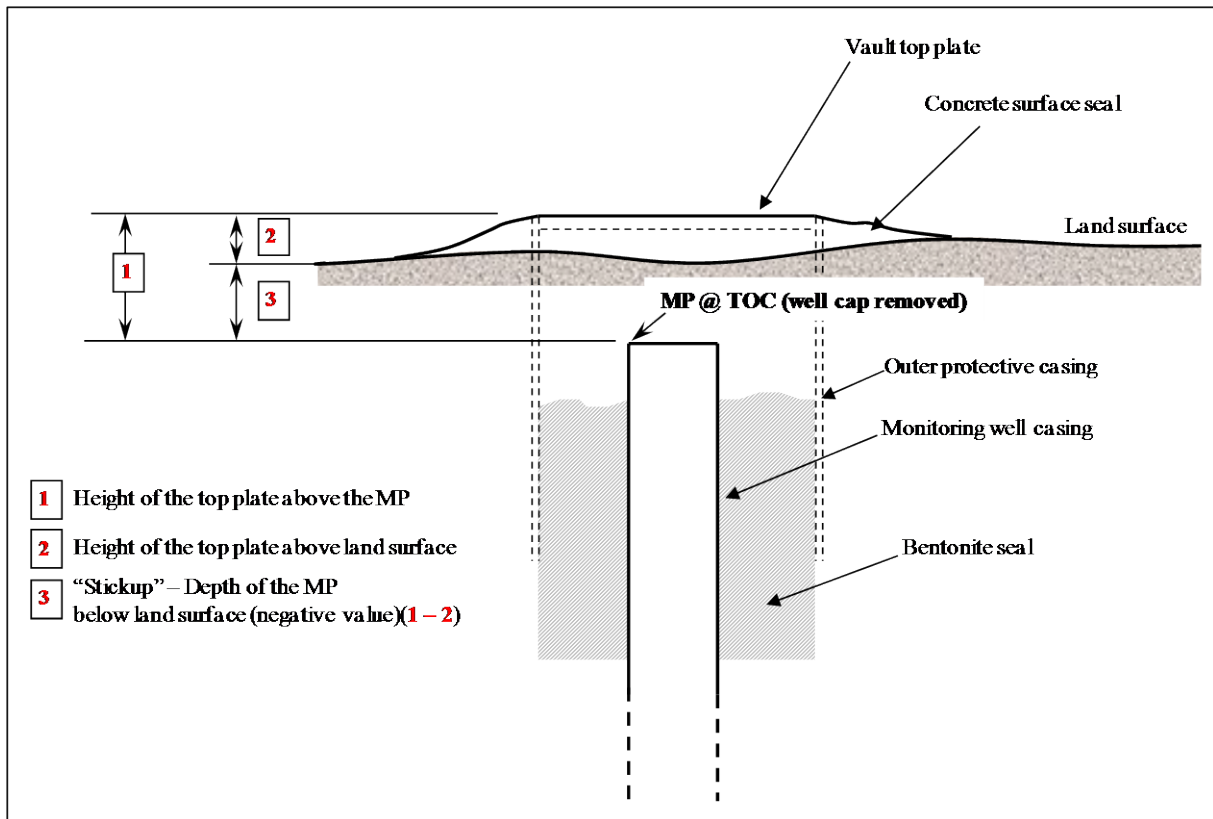


Figure 2. Determining the MP Depth-Below-Land-Surface for a Flush-Mount Monitoring Well

6.5 Establish a Measuring Point (MP) on Water Supply Wells

6.5.1 The majority of domestic or small public water supply wells are completed with an above-ground metal casing. After removing the well cover establish a permanent MP on the casing rim as you would for an above ground monitoring well (Section 6.2).

6.5.2 Other water supply wells may have a more complex and hard to remove well cover with screened pressure equilibration vents, electric component boxes, and attached riser pipes (Figure 3). In this situation, there is often a small opening (sometimes plugged with a nut) on the well cover that is designed to serve as an instrument port, allowing down-hole measurements without the need to remove the cover. Under this circumstance, remove the plug, and establish the MP location at the top surface of the port. Determine and record the height of MP above LSD as described earlier. If no access port is available you may need to remove a portion of the vent pipe, or drill a port through the cover (obtain the well owner's permission) to simplify access to the well. To eliminate the chance of contact with the pump, some larger production wells will have a dedicated pipe inside the well casing specifically for water level measurement.

6.5.3 Record the location and date of the MP in the field data sheets.

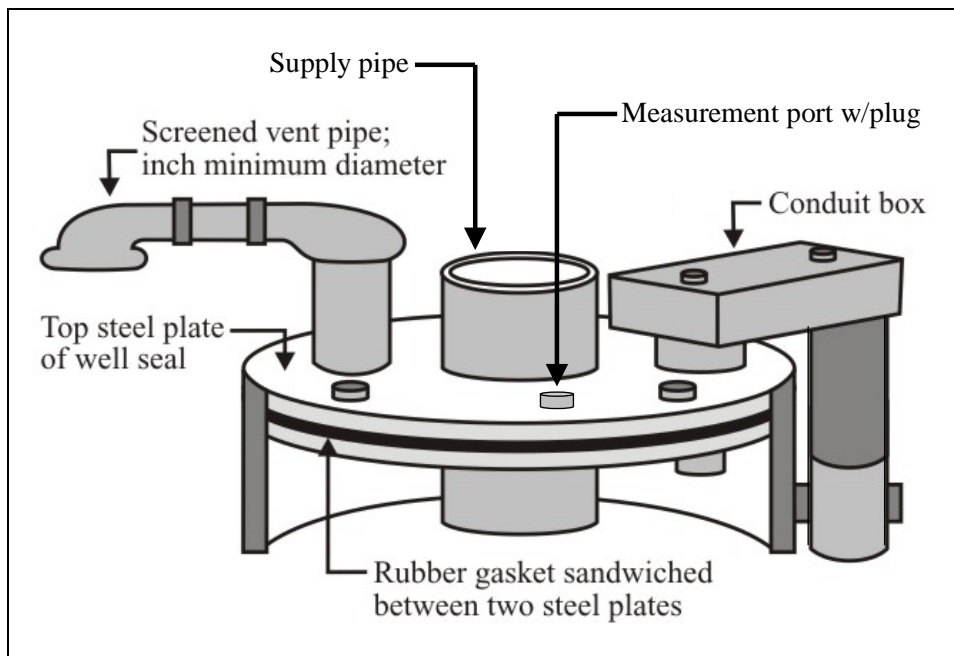


Figure 3. Water Supply Well with a Water-Level Measurement Port

## 6.6 Equipment Cleaning, Disinfection or Decontamination

- 6.6.1 Water level measuring equipment must be cleaned, disinfected or decontaminated prior to and after use in each well. The cleaning procedure depends on the type of well being measured (i.e. observation well, regulated facility monitoring well, or water supply well). It is recommended that gloves (Nitrile/latex) be worn when cleaning measuring equipment. This will help maintain sanitary conditions of the cleaned tape and will protect the sampler from the cleaning products being used. When not in use, equipment should be placed on a clean surface, such as a clean plastic sheet. Equipment should never be placed on bare soil prior to using it in a well.
- 6.6.1.1 Observation wells: rinse probe and any submerged tape with deionized water. Wipe or air dry.
- 6.6.1.2 Regulated facility monitoring well: wash probe and any submerged tape in a laboratory grade soap (i.e. Liquinox) solution, followed by deionized water rinse. If the equipment is used in a well that organic contamination is suspected or known, the equipment should be rinsed with an appropriate solvent (i.e., methanol, isopropyl alcohol, acetone), then triple rinse the equipment with deionized water. Place equipment on a clean surface to air dry. ***(To prevent cross-contamination, when possible measurements should be taken from the least to the most contaminated well).***
- 6.6.1.3 Water supply well: disinfect probe and any potentially submerged tape with dilute chlorine bleach. Depending on how much of the tape is submerged the equipment can be sprayed with disinfectant, soaked in a bucket of disinfectant or wiped with a clean disinfectant soaked towel. Rinse equipment with deionized water. Dry equipment with a clean towel or air dry. ***(It is important to properly disinfect all equipment being used in water supply wells to prevent the introduction of coliform or iron bacteria into the water supply).***

## 6.7 Electric-Tape Maintenance and Calibration

- 6.7.1 Electric-tapes (e-tapes) are the most common device used for determining depth-to-water in wells. Before being used in the field an electric-tape should be inspected and calibrated. Check electric-tapes for wear, kinks, frayed electrical connections, breaks and possible stretch. Test the battery and verify a working electrical connection. Electric-tapes should be calibrated annually or more frequently if it is used often or if the tape has been subjected to abnormal stress that may have caused it to stretch.
- 6.7.2 Calibrate the electric-tape against a reference steel measuring tape as follows:
- 6.7.2.1 Lay the electric tape and reference tape out straight on a flat surface.
- 6.7.2.2 Position the zero marks of both tapes exactly opposite one another. On the electric tape this will be the point on the probe's sensor that first indicates contact with the water.



- 6.7.2.4.2 Periodically recheck the cut value/tape correction factor by measuring the spliced electric-tape with a steel reference tape.
- 6.7.2.4.3 If the electric-tape has stretched, the entire length of the tape must be checked against the reference tape to determine if the stretch is linear throughout the entire tape. A non-linear error indicates the tape has stretched unevenly. In such cases the stretched portion should be removed and the tape recalibrated. If the length of removed tape is so long that it renders the tape unusable for most applications, then the tape should be replaced.
- 6.7.2.5 If an electric tape needs a correction value it should be determined to the nearest 0.01-foot. Record the correction value on the calibration sheet and on the body of the tape reel.
- 6.7.3 Test the battery and verify a working electrical connection as follows:
  - 6.7.3.1 Some electric-tape meters have a “Test” dial or button to confirm that the electrical circuit is in good working order.
  - 6.7.3.2 If the electric-tape does not have a “test” button, the probe’s sensor should be placed in tap water to complete the electrical circuit. Observe whether the meter’s indicators (needle, light, and/or buzzer) indicate a closed circuit. If the electric tape has multiple indicators (i.e. light and buzzer), confirm that the indicators operate simultaneously. If they do not, determine which is more accurate and record in a permanent manner on the body of the tape reel.
  - 6.7.3.3 If the electric-tape has an indicator sensitivity control, check it at different ranges. The sensitivity control can be adjusted to sharpen the indicators response as the electric-tape probe moves across the water surface. The sensitivity setting should be adjusted to provide a ‘crisp’ indication as the zero point of the electric-tape makes contact with the water. A weak electrical response under all sensitivity settings suggests a weak battery.

## 6.8 Depth-to-Water Measurement Using an Electric-Tape

- 6.8.1 Electric-tapes (e-tapes) are the most common device for measuring depth-to-water in wells because they are easy to use, allow for efficient repeat measurements, can be used to make a series of measurements in rapid succession (i.e. during purging or an aquifer test), and are safer than steel-tapes in wells with operating pumps.
- 6.8.2 Before going into the field prepare field data sheets for each well location. It can be helpful to bring any previous measured water level data for the well.
- 6.8.3 Depth-to-water measurements should be collected prior to inserting any other field equipment into a well, prior to well depth measurement, and prior to purging and sampling.

- 6.8.4 Gain access to the well measuring point by removing the well cover, the well cap, the well access port plug, etc. For monitoring wells on regulated facilities you will probably need a key to remove the well cap.
- 6.8.4.1 If organic contaminants are suspected, the head space of the well can be monitored with a photoionization detector (PID) or flame ionization detector (FID). Record the results in the field data sheets.
- 6.8.4.2 If there is a pressure transducer attached to the well cap, carefully note the initial position of the cap. Lift and stabilize the cap just enough to allow entry of the probe and tape. If possible, time the hand measurement during a 'sleep' period of the data logger.
- 6.8.5 Allow the well to equilibrate for a few minutes. Newly constructed and developed wells should be allowed to equilibrate a minimum of 24 hours. In low yield situations, recovery of water levels to static equilibrium may take longer.
- 6.8.6 Check that the measuring point (MP) is clearly marked. If a new measuring point needs to be established, follow the applicable procedures described in Sections 6.2 to 6.5. Do not use paint or create casing-material filings until after water level measurement and sampling have been completed to avoid sample contamination.
- 6.8.7 Clean or disinfect the lower portion of the electric-tape using the procedures described in Section 6.6.
- 6.8.7.1 It is recommended to wear some type of protective gloves (i.e. Nitrile, latex) from this point on to increase sanitary conditions and protect the individual performing the work.
- 6.8.8 If available, set the sensitivity control on the electric-tape to a mid-range setting.
- 6.8.9 Slowly lower the probe into the well until the indicator shows that contact with the water surface is made and the electric-tape circuit is closed. To confirm contact with the distinct water boundary, slowly raise and lower the electric-tape probe in and out of the water column. If necessary, adjust the sensitivity setting of the meter to provide a 'crisp' indication of the water surface.
- 6.8.9.1 To protect the electric-tape, as you lower and raise the probe, avoid letting the tape rub across the top edge of the well casing rim.
- 6.8.9.2 If taking depth-to-water measurements in wells with dedicated pumps, lower the electric-tape at a location that is away from pump power cables and other obstacles. If the electric-tape goes slack before the sensor indicates contact with the water, the probe is probably hung up in the well. Carefully raise and re-lower the tape as necessary.

- 6.8.9.3 On occasion, condensation on the interior casing wall and probe can prematurely trigger the electric-tape indicator giving a false positive reading. This is especially true in small diameter (< 2”) wells. In this situation it can help to center the tape in the well casing above the water level and lightly shake the tape to remove the excess water on the probe.
- 6.8.9.4 When measuring depth-to-water in small diameter (<2”) wells, select an electric-tape with a small probe. Large probes can raise the static water level in a well by displacing the water.
- 6.8.9.5 Oil or other product floating on the water column can insulate the contacts of an electric-tapes sensor and give false readings. For accurate depth-to-water measurements in wells containing separate phase product, a special product/water level indicator should be used. To compensate for the effect the floating product has on the water column, calculations will need to be applied to estimate the depth-to-water.
- 6.8.10 At the precise location the indicator shows contact with the water surface, pinch the tape between your finger-nails at the point exactly opposite the MP. This position on the electric-tape is referred to as the “Hold” (Figure 5).
- 6.8.11 Read the depth-to-water.
  - 6.8.11.1 If using an electric-tape with a printed scale, note your nail position on the scale to the nearest 0.01 foot.
  - 6.8.11.2 If using an electric-tape with 1-foot interval marks, measure the distance between your nail or hold position and the nearest marker using a steel hand measuring tape. If the marker used is below the hold position then add the distance to the markers value to determine DTW. If the marker used is above the nail or hold position, then subtract the distance from the marker’s value to determine DTW. Measure to the nearest 0.01-foot.
- 6.8.12 Repeat the measurement to ensure reproducibility and accuracy.
  - 6.8.12.1 Make all measurements using the same sensitivity setting on the indicator scale, light intensity, or sound so that DTW measurements will be consistent.
  - 6.8.12.2 Repeat measurements should be within the following accuracy standards depending on the depth of application:
    - ±0.02 feet for electric-tape measurements <250 feet deep,
    - ±0.04 feet for electric-tape measurements between 250-500 feet deep, or
    - ±0.1 feet for electric-tape measurements >500 feet deep.(Accuracy measurements are set to compensate for tape expansion and stretch when measuring deep water levels.)

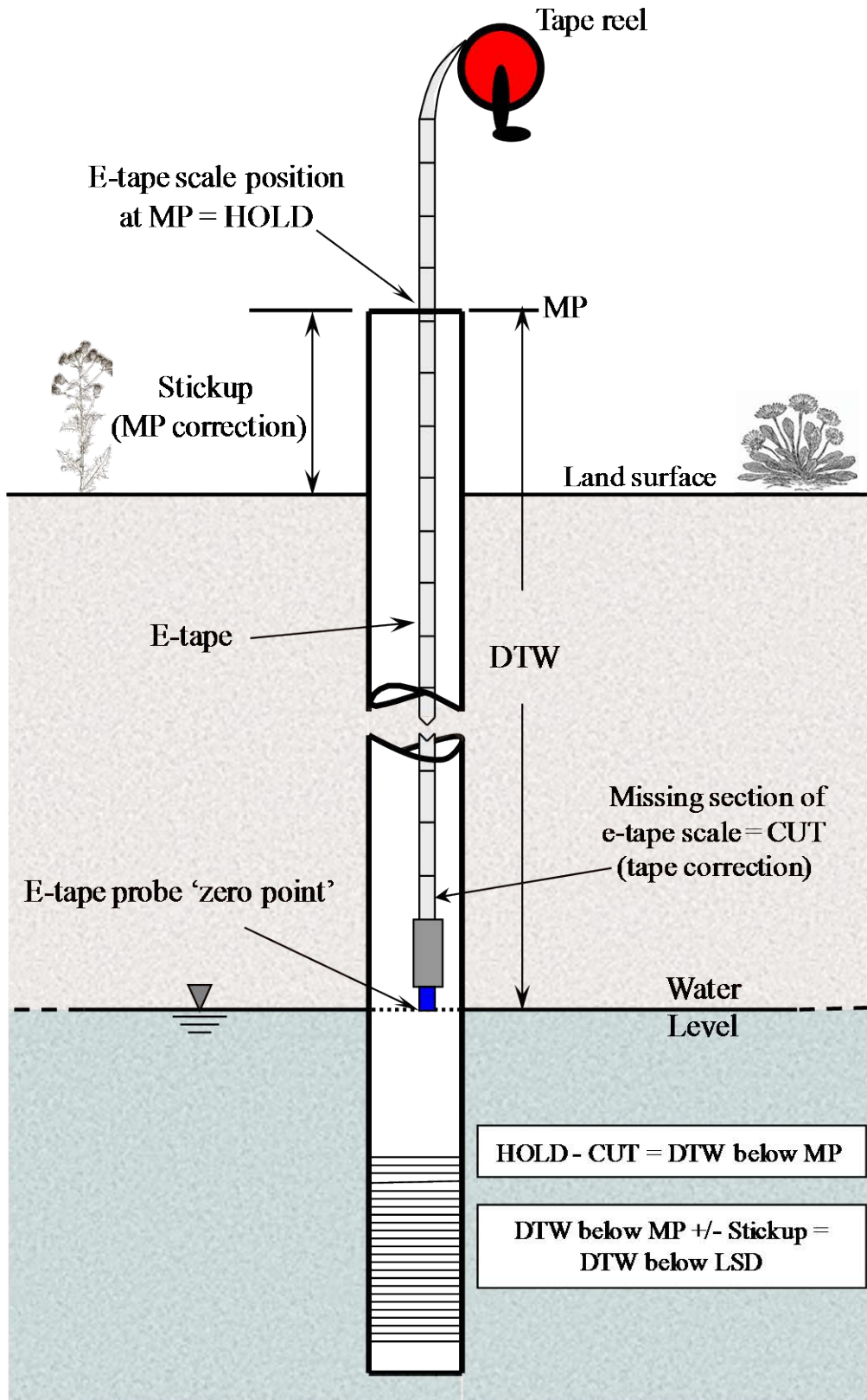


Figure 5. Example Depth-to-Water Measurement using an Electric-tape



- 6.8.12.3 If repeated check measurements are not reproducible, determine and document the reason for the non-static water level condition (i.e. water level is still equilibrating, well pump is operating, etc.). Record these observations on the field data sheet.
- 6.8.13 Record the static tape number to the nearest 0.01-foot on the field data sheets as the “Hold” value (Figure 6). Record the date and time the measurement was collected.
- 6.8.14 If the tape has been repaired or spliced a cut value or tape correction must be applied to the Hold value to determine depth-to-water below the measuring point (MP).
- 6.8.14.1  $\text{Hold (tape reading held at the MP) - Cut (missing section of electric-tape/tape correction) = Depth-to-water below MP.}$  If the tape has no cut value or tape correction, then the Hold value = the depth to water below the MP.
- 6.8.15 To determine depth-to-water in relation to the land surface datum (LSD) apply the stickup/MP correction value.
- 6.8.15.1  $\text{DTW below MP +/- Stickup (MP correction) = Depth-to-water below LSD.}$
- 6.8.15.2 If the MP is above the land surface, subtract the distance between the MP and the LSD (i.e. stickup) from the depth-to-water measurement.
- 6.8.15.3 If the MP is below the land surface, precede the MP correction value (i.e. stickup) with a minus (-) sign and subtract the distance between the MP and the LSD from the depth-to-water measurement.
- 6.8.16 After completing all well measurements clean or disinfect the section of the electric-tape that was submerged in the well water as described in section 6.6. Store the equipment for transport to the next sample location.
- 6.8.17 When all work at the well site is complete, properly close the well.
- 6.8.18 Note any physical changes in the field data sheets, such as erosion or cracks in the protective concrete pad or alterations to the well casing. If well depth was measured as described in section 6.12, record the value and report any variation in the depth.
- 6.9 Steel-Tape Maintenance and Calibration
- 6.9.1 Graduated steel-tapes are generally accepted as the most accurate measurement method for determining depth-to-water in a well ( $\pm 0.01$  ft) that is 200-feet or less below the land surface.
- 6.9.2 Graduated steel-tapes in good condition do not normally need to be calibrated. However, if the steel-tape shows obvious signs of damage or has been subjected to abnormal stress then it should be compared to a reference steel measuring tape.

- 6.9.3 Before being used in the field a steel-tape should be inspected for rust, kinks or breaks.
- 6.9.4 If the steel-tape is new, be sure the black sheen on the tape has been dulled so that the tape will retain the chalk.
- 6.9.5 Attach a breakaway weight to the tape that is constructed of stainless steel or other non-contaminating material to protect groundwater quality in the event that the weight is lost in the well.

## 6.10 Depth-to-Water Measurement Using a Steel-Tape

- 6.10.1 Steel-tapes are considered the most accurate method for measuring depth-to-water in non-flowing wells.
- 6.10.2 Before going into the field prepare field data sheets for each well location. It can be helpful to bring any previous measured water level data for the well.
- 6.10.3 Depth-to-water measurements should be collected prior to inserting any other field equipment into a well, prior to well depth measurement, and prior to purging and sampling.
- 6.10.4 Gain access to the well measuring point by removing the well cover, the well cap, the well access port plug, etc. For monitoring wells on regulated facilities you will probably need a key to remove the well cap.
  - 6.10.4.1 If organic contaminants are suspected, the head space of the well can be monitored with a photoionization detector (PID) or flame ionization detector (FID). Record the results in the field data sheets.
  - 6.10.4.2 If there is a pressure transducer attached to the well cap, carefully note the initial position of the cap. Lift and stabilize the cap just enough to allow entry of the probe and tape. If possible, time the hand measurement during a 'sleep' period of the data logger.
- 6.10.5 Allow the well to equilibrate for a few minutes. Newly constructed and developed wells should be allowed to equilibrate for a minimum of 24 hours. In low yield situations, recovery of water levels to static equilibrium may take longer.
- 6.10.6 Check that a measuring point (MP) is clearly marked on the well. If a new measuring point needs to be established, follow the applicable procedures described in Sections 6.2 to 6.5. Do not use paint or create casing-material filings until after water level measurement and sampling have been completed to avoid sample contamination.
- 6.10.7 Clean or disinfect the lower portion of the steel-tape and breakaway weight as described in Section 6.6. Be sure the steel-tape is completely dry so the chalk adheres to the tape.

- 6.10.7.1 It is recommended to wear some type of protective gloves (i.e. Nitrile, latex) from this point on to increase sanitary conditions and protect the individual performing the work
- 6.10.8 Chalk the lower few feet of the steel-tape by pulling the tape across a piece of blue carpenter's chalk.
- 6.10.9 If available, use previous water level measurement data to determine the length of tape that should be lowered into the well. If previous data is not available, an electric-tape may be used to provide an estimate.
- 6.10.10 Slowly lower the weight and tape into the well until the bottom end of the tape is submerged below the water. Avoid splashing as the weight enters the water. Pinch the tape between your finger-nails at the selected whole-foot mark. Continue to lower the end of the tape into the well until the selected mark on the tape is exactly opposite the MP (Figure 7). Record the tape number to the nearest 0.01-foot on the field data sheets as the "Hold" value (Figure 6).
- 6.10.10.1 If possible, lower the steel-tape down the center of the well.
- 6.10.10.2 If taking depth-to-water measurements in wells with dedicated pumps, lower the steel-tape at a location that is away from pump power cables and other obstacles. An accurate measurement cannot be made if the tape does not hang plumb. (***Depth-to-water should not be measured with a steel-tape if the pump is operating***).
- 6.10.10.3 If the steel-tape goes slack before contact with the water, the tape is probably hung up in the well. Carefully raise and re-lower the tape as necessary.
- 6.10.10.4 The chalked steel-tape should not be in the water longer than a few seconds to avoid water wicking up the chalked surface.
- 6.10.10.5 Due to problems keeping the chalk dry, steel tapes are not effective in wells with cascading water or heavy condensation on the interior of the well casing.
- 6.10.10.6 Steel-tapes may be used in wells that have oil floating on the water column. Instead of carpenters chalk a commercially available water-detector paste can be used that will detect the presence of water in the oil. Apply the paste to the lower end of the tape. The top of the oil shows as a wet line, and the top of the water shows as a distinct color change. To compensate for the effect the floating product has on the water column, calculations will need to be applied to estimate the depth-to-water.
- 6.10.11 Quickly reel the tape to the surface before the wetted chalk mark dries and becomes difficult to read. The wetted chalk/dry chalk mark identifies the distinct water boundary. This position on the steel-tape is referred to as the "Cut" (Figure 7).

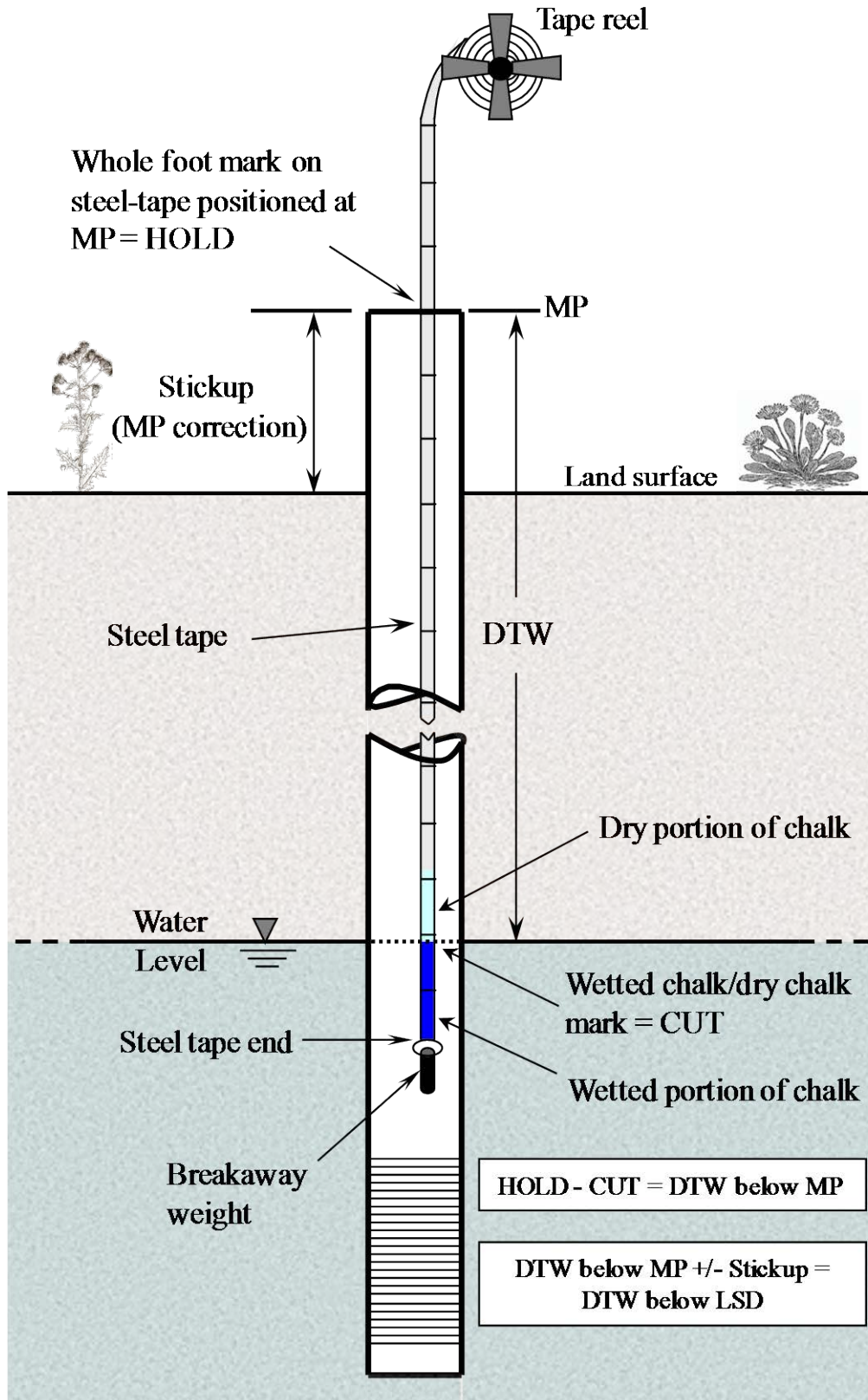


Figure 7. Example Depth-to-Water Measurement using a Graduated Steel-Tape

- 6.10.12 Identify and read the tape position on the wetted chalk/dry chalk mark.
- 6.10.12.1 If using a steel-tape with a printed scale, note the wetted chalk/dry chalk position on the scale to the nearest 0.01 foot.
- 6.10.12.2 If using a steel-tape with 1-foot interval marks, measure the distance between the wetted chalk/dry chalk position and the nearest marker using a steel hand measuring tape. If the marker used is below the wetted chalk/dry chalk position, then add the distance to the markers value to determine the Cut value. If the marker used is above the wetted chalk/dry chalk position, then subtract the distance from the markers value to determine the Cut value. Measure to the nearest 0.01-foot.
- 6.10.13 Record this value as the “Cut” on the field data sheet (Figure 6).
- 6.10.14 Subtract the “Cut” value from the “Hold” value and record the difference as the DTW below the MP. Record the date and time the measurement was collected.
- 6.10.14.1  $\text{Hold (tape reading held at the MP)} - \text{Cut (wetted chalk/dry chalk mark value)} = \text{Depth-to-water below MP.}$
- 6.10.15 Repeat the measurement to ensure reproducibility and accuracy. Record subsequent measurements.
- 6.10.15.1 Clean, dry, and re-chalk the tape.
- 6.10.15.2 The check measurement should be made using a different MP hold value than that used for the original measurement.
- 6.10.15.3 Repeat measurements should be accurate to within  $\pm 0.02$  foot. This method is most accurate for depth-to-water measurements less than 200 feet below the land surface. Tape expansions and stretch need to be considered if the depth is greater than 200 feet.
- 6.10.15.4 If repeat measurements are not reproducible, try to establish and document the reason for the non-static water level condition (i.e. water level is still equilibrating, water level is declining due to pumping of a nearby well). Record these observations in the field data sheets.
- 6.10.16 To determine depth-to-water in relation to the land surface datum (LSD) apply the stickup/MP correction value.
- 6.10.16.1  $\text{DTW below MP} \pm \text{Stickup (MP correction)} = \text{Depth-to-water below LSD.}$
- 6.10.16.2 If the MP is above the land surface, subtract the distance between the MP and the LSD (i.e. stickup) from the depth-to-water measurement.

- 6.10.16.3 If the MP is below the land surface, precede the MP correction value (i.e. stickup) with a minus (-) sign and subtract the distance between the MP and the LSD from the depth-to-water measurement.
- 6.10.17 After completing all well measurements, clean the exposed portion of the tape. To prevent microbial cross-contamination of other wells, the tape can be disinfected using commercially available hypochlorite wipes or a dilute chlorine solution. Rinse with deionized water and dry the tape after each use. Do not store a steel tape while dirty or wet.
- 6.10.18 When all work at the well site is complete, properly close the well.
- 6.10.19 Note any physical changes in the field data sheets, such as erosion or cracks in the protective concrete pad or alterations to the well casing. If well depth was measured as described in section 6.12, record the value and report any variation in the depth.
- 6.11 Depth-to-Water Measurement Using an Existing Air Line
- 6.11.1 Depth-to-water is measured using an existing air line when an access port for an electric- or steel-tape is not present, the well cap is not easily removed, or there is water turbulence due to cascading water or an operating pump. Air lines are typically installed in high capacity water supply wells.
- 6.11.2 Prepare field data sheets for each well location. It can be helpful to bring any previous measured water level data for the well.
- 6.11.3 Remove cap or plug from the air line.
- 6.11.4 If needed allow the well to equilibrate.
- 6.11.5 Check that a measuring point (MP) is clearly marked on the well. If a new measuring point needs to be established, follow the applicable procedures described in Sections 6.2 to 6.5.
- 6.11.6 Attach the pressure gage to the air line and air supply (Figure 8).
- 6.11.6.1 Use a 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 the air line).
- 6.11.6.2 For the best accuracy, use a pressure gage for which the reading will fall within the middle one-third of the gage's range.
- 6.11.7 Pump air into the air line until the pressure shown on the gage levels off at a constant maximum, indicating that all the water has been forced out of the line.

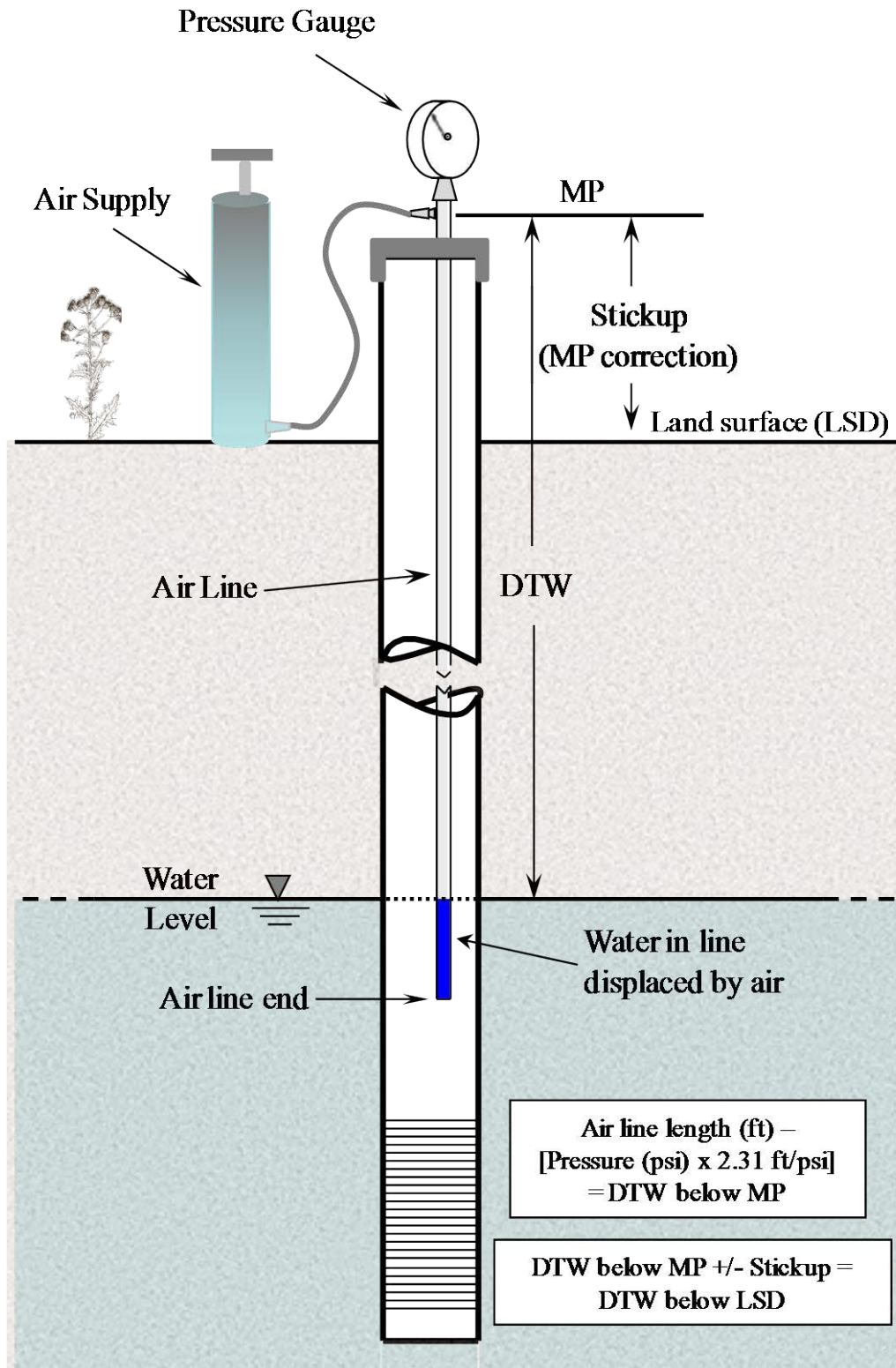


Figure 8. Example Depth-to-Water Measurement using an Air Line

- 6.11.8 Record the pressure reading (psi). The gauge reading is the pressure required to force water out of the air line which is also the pressure of the water column in the well above the bottom of the air line. Record the date and time of the measurement.
- 6.11.9 Determine depth-to-water below the measuring point (MP).
- 6.11.9.1 Multiply the pressure reading (psi) times 2.31 (ft/psi) to determine the length of the water column that was removed from the air line.
- 6.11.9.2 Subtract the length of the water column removed from the total air line length to obtain the depth-to-water below the MP.
- 6.11.9.3  $\text{Air line length (ft)} - (\text{Pressure gage reading (psi)} \times 2.31 \text{ ft/psi}) = \text{DTW below MP}$
- 6.11.10 To determine depth-to-water in relation to the land surface datum (LSD) apply the stickup/MP correction value.
- 6.11.10.1  $\text{DTW below MP} \pm \text{Stickup (MP correction)} = \text{Depth-to-water below LSD}$
- 6.11.10.2 If the MP is above the land surface, subtract the distance between the MP and the LSD (i.e. stickup) from the depth-to-water measurement.
- 6.11.10.3 If the MP is below the land surface, precede the MP correction value (i.e. stickup) with a minus (-) sign and subtract the distance between the MP and the LSD from the depth-to-water measurement.
- 6.11.11 Record the water level data on field data sheets to an accuracy of 1 ft.
- 6.11.12 When all work at the well site is complete, properly close the well.
- 6.11.13 Note any physical changes in the field data sheets, such as erosion or cracks in the protective concrete pad or alterations to the well casing.
- 6.12 Total Well Depth Measurement Using a Weighted Tape
- 6.12.1 Prepare field data sheets for each well location. It can be helpful to bring any previous total depth measurement data for the well.
- 6.12.2 Use a calibrated measuring device.
- 6.12.3 Gain access to the well measuring point by removing the well cover, the well cap, the well access port plug, etc. For monitoring wells on regulated facilities you will probably need a key to remove the well cap.
- 6.12.4 Remove any dedicated down-hole pumps or instrumentation.

- 6.12.5 Check that the measuring point (MP) is clearly marked. If a new measuring point needs to be established, follow the applicable procedures described in Sections 6.2 to 6.5.
- 6.12.6 Clean or disinfect the portion of tape that will be lowered below the water level using the procedures described in Section 6.6
  - 6.12.6.1 It is recommended to wear some type of protective gloves (i.e. Nitrile, latex) from this point on to increase sanitary conditions and protect the individual performing the work.
- 6.12.7 Slowly lower the tape into the well until the weighted end reaches the bottom of the well and the tape becomes slack.
  - 6.12.7.1 To protect the tape, as you lower it into the well avoid letting the tape rub across the top edge of the well casing rim.
- 6.12.8 Raise the tape until it is taut (the weighted end is vertical and off the bottom of the well). Slowly lower the tape again to refine the point where the tape goes slack.
- 6.12.9 When the weighted tape touches the bottom of the well, pinch the tape between your finger-nails at the point opposite the MP. This position on the tape is referred to as the “Hold”.
- 6.12.10 Read the tape scale held at the MP.
  - 6.12.10.1 If using a tape with a printed scale, note your nail position on the scale to the nearest 0.01 foot.
  - 6.12.10.2 If using a tape with 1-foot interval marks, measure the distance between your nail position and the nearest marker using a steel hand measuring tape and either add or subtract the value from the marker that is used. If the marker used is below the hold position then add the distance to the markers value to determine the well depth. If the marker used is above the nail or hold position, then subtract the distance from the marker’s value to determine well depth. Measure to the nearest 0.01-foot.
- 6.12.11 Record the well depth measurement on the field data sheets as the “Hold” value. Record the date and time the measurement was collected.
- 6.12.12 If the tape has been repaired or spliced apply the cut value/tape correction to the Hold value to determine total well depth below the measuring point (MP).
  - 6.12.12.1  $\text{Hold (tape reading held at the MP) + (Length of weight interval) - Cut (missing section of tape/tape correction) = Total well depth in feet below MP}$
- 6.12.13 Repeat the measurement to ensure reproducibility and accuracy. Record subsequent measurements.

- 6.12.14 To determine well depth in feet in relation to the LSD apply the stickup/MP correction value.
- 6.12.14.1 Total well depth below MP +/- Stickup (MP correction) = Well depth below LSD.
- 6.12.14.2 If the MP is above the land surface, subtract the distance between the MP and the LSD (i.e. stickup) from the well depth measurement.
- 6.12.14.3 If the MP is below the land surface, precede the MP correction value (i.e. stickup) with a minus (-) sign and subtract the distance between the MP and the LSD from the well depth measurement.
- 6.12.15 After completing all well measurements clean or disinfect the section of the tape that was submerged in the well water as described in section 6.6. Store the equipment for transport to the next sample location.
- 6.12.16 When all work at the well site is complete, properly close the well.
- 6.12.17 Note any physical changes, such as erosion or cracks in the protective concrete pad, alterations to the well casing, or variation in the total depth of the well, in the field data sheets.

## **7.0 Records Management**

- 7.1 For each site where well depth or depth-to-water measurements are being collected, the following data should be recorded on the field data sheets:
  - 7.1.1 Well site name
  - 7.1.2 Well tag #, if available
  - 7.1.3 Well location (i.e. coordinates and address)
  - 7.1.4 Description of measuring point location
  - 7.1.5 Measuring point height (stickup)
  - 7.1.6 Well depth
  - 7.1.7 Depth-to-water or total well depth measurement, including Hold, Cut and any corrections that need to be applied.
  - 7.1.8 Date and time of measurement
  - 7.1.9 Observations or remarks on depth-to-water or well depth measurements or conditions of the well site that may affect data quality.
- 7.2 All hardcopy documentation, such as field data sheets, are kept and maintained by the project lead. At the completion of a project, hardcopies are boxed and moved to EAP archives.

- 7.3 Well location information and data will be entered into Ecology's Environmental Information Management (EIM) System. Required location information for wells is as follows. However, data requirements for EIM change as the program is updated, therefore it should be checked at the start of a new project.
- 7.3.1 Location Information
- 7.3.1.1 User location ID - *Unique user-assigned ID to identify the field location in EIM.*
- 7.3.1.2 Location Name - *Unique descriptive name for a field location.*
- 7.3.1.3 Location Type - *Describes the field Location in relation to the surrounding environment (i.e. land for well locations).*
- 7.3.1.4 Location Status - *Current status with respect to monitoring activity.*
- 7.3.1.5 Location Geometric Type - *Identifies which of three spatial type's best describes the field Location (i.e. wells are identified as a point).*
- 7.3.1.6 Location Well Flag - *A Yes (Y) or No (N) flag that indicates whether a field Location is a Well. Additional data must be entered for a Well Location.*
- 7.3.1.7 Location Description - *A short narrative description of the field location that can be used by others to locate the site in the field.*
- 7.3.2 Location Coordinate Reference System
- 7.3.2.1 Location Coordinates Reference System - *Coordinate referencing system used when field Location geographic position is entered into EIM (i.e. Latitude/Longitude (Degrees-Minutes-Seconds); Latitude/Longitude (Decimal Degrees); State Plane Coordinate System, Universal Transverse Mercator System).*
- 7.3.2.2 EIM converts all locations into NAD83HARN (Latitude/Longitude (Decimal Degrees)).
- 7.3.3 Location Horizontal Information
- 7.3.3.1 Horizontal Reference Datum - *Model used to match the horizontal position of features on the ground to coordinates and Locations on a map (i.e. NAD83).*
- 7.3.3.2 Horizontal Accuracy Measure - *The range within which the measured value of the horizontal coordinate for the field Location may vary from the actual value.*
- 7.3.3.3 Horizontal Collection Methods - *Technique used to collect the horizontal coordinates of a field Location (i.e. address, GPS, surveyed).*
- 7.3.3.4 Horizontal Reference Point - *General description of the geographic position of the field Location in relationship to the ground.*
- 7.3.3.5 Source Map Scale - *Scale of the base map (if applicable) used to determine the geographic position of the field Location.*
- 7.3.4 Location Vertical Information
- 7.3.4.1 Vertical Measure and Unit of Measure - *The elevation of the land surface at a field Location.*
- 7.3.4.2 Vertical Reference - *The reference point used to calculate the Elevation (Vertical Measure) of a field Location (i.e. mean sea level).*
- 7.3.4.3 Vertical Collection Methods - *The technique used to calculate the Elevation (Vertical Measure) of a field Location (i.e. map, GPS, surveyed).*
- 7.3.4.4 Vertical Datum - *Model used to match the Elevation (Vertical Measure) of field Locations on the ground to field Locations on a map (i.e. NAVD88).*

- 7.3.4.5 Vertical Accuracy - *Indicates the accuracy of a field Location's Elevation (Vertical Measure).*
- 7.3.5 Well Location Information
- 7.3.5.1 Well ID – *Sub ID for well clusters or multiple completions at a single well (i.e. 1,2,3).*
- 7.3.5.2 Well Tag Number - *Unique six-digit alpha-numeric identifier stamped on an aluminum tag.*
- 7.3.5.3 Well Owner Name - *This information is not made public without filing a formal request.*
- 7.3.5.4 Well Status - *Describes whether a well is still in existence or has been abandoned.*
- 7.3.5.5 Well Use - *Describes the primary use of the well (i.e. monitor, withdrawal).*
- 7.3.5.6 Well Water Use - *Describes the primary use of the water from the well (i.e. water supply, irrigation).*
- 7.3.5.7 Well Construction Start and End Dates - *Dates well construction was started and completed.*
- 7.3.5.8 Well Construction Method - *Method used to create the borehole and construct the well.*
- 7.3.5.9 Well Completion Depth and Unit of Measure - *Final completion depth below land surface for a well as determined during initial construction.*
- 7.3.5.10 Well Hole Depth and Unit of Measure – *Depth below land surface to the bottom of the borehole on completion of drilling.*
- 7.3.5.11 Well Maximum Casing Diameter and Unit of Measure - *Diameter of the outermost permanent casing used to complete the well.*
- 7.3.5.12 Well Completion Method - *Method of well completion (i.e. open hole, gravel pack with screened casing).*
- 7.3.5.13 Well Measuring Point Name - *Name used to describe a unique reference point on a well from which depth-to-water measurements are routinely made (i.e. MPI).*
- 7.3.5.14 Well Measuring Point Height and Unit of Measure - *Distance (height) from the well measuring point to the land surface at the well.*
- 7.3.5.15 Well Measuring Point Description - *Description of the physical point on the well from which water levels are measured.*
- 7.3.5.16 Well Measuring Point Effective Date - *Date when measuring point was first used.*
- 7.3.5.17 Well Measuring Point End Date - *Date when a measuring point was abandoned.*
- 7.3.6 Well interval information should be entered into EIM if a well drillers log is available. This information describes the well or borehole by interval and can include information on geologic unit, well casing materials (type, depth, and diameter), well finish (screen, open hole), and fill material (type and volume).

## **8.0 Quality Control and Quality Assurance Section**

- 8.1 The following general quality assurance/quality control (QA/QC) procedures apply:
- 8.1.1 Adherence to the standard operating procedures (SOP) for data collection by all personnel.

- 8.1.2 All instrumentation must be operated in accordance with the operating instructions as supplied by the manufacturer, unless otherwise specified in the projects Quality Assurance Project Plan (QAPP).
- 8.1.3 Repeat measurements of the well depth or depth-to-water at each location must be made to ensure reproducibility and accuracy. Repeat measurements should be within the method's specified accuracy standards. If repeated check measurements are not reproducible, then a reason needs to be established and documented.
- 8.1.4 All data must be documented on the field data sheets.

## **9.0 Safety**

- 9.1 Field work done in connection with well depth and depth-to-water measurements at well locations should follow protocols described in the Environmental Assessment Program Safety Manual (Ecology 2006). A working knowledge of sections 'Groundwater Sampling and Water-Level Measurements' and 'Hazardous Waste Sites' in Chapter 2 is expected.
- 9.2 All EA Program field staff who work on hazardous waste sites are required to complete and maintain certification in FIRST AID/CPR and the 40-hour Hazardous Materials Safety & Health Training.

## **10.0 References**

- 10.1 Ecology, 2006. Environmental Assessment Program Safety Manual, Olympia, WA
- 10.2 Ecology, 2008. Environmental Information Management Database. Washington State Department of Ecology Internet Site at <http://www.ecy.wa.gov/eim/>
- 10.3 EPA, 2002. Standard Operating Procedure #2043 – Manual Water Level Measurement. Response Engineering and Analytical Contract #68-C99-223 223.
- 10.4 Nielsen, D.M. and G.L. Nielsen, 2007. The Essential Handbook of Groundwater Sampling. CRC Press/Taylor and Francis Group, Boca Raton, FL, 2007.
- 10.3 USGS, 2005. Quality-Assurance Plan for Ground-Water Activities, U.S. Geological Survey, Washington Water Science Center. Open File Report 2005-1126.