Measuring Groundwater Levels in Wells

Oregon Water Resources Department

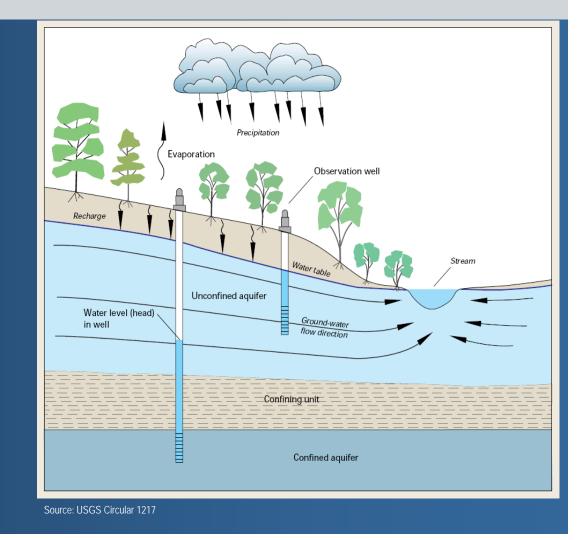


Presentation Outline

- What is a groundwater level measurement?
- Why measure the water level in a well?
- Well Documentation
- Measurement Documentation
- Water Level Meters
- Well Measuring Points
- Water Level Measurement
- Measurement Challenges

What is a ground water level measurement?

- A measurement of the water level in a well.
- Static (non-pumping) ground water level measurements represents conditions in the surrounding aquifer.
 - Measurements over time give a better representation of aquifer conditions.



Why Measure the Groundwater Level in a Well?

- Groundwater Level Data
 Serve Multiple Uses.
- Static (non-pumping) groundwater level data helps determine 3-D flow directions & water level trends (short & long-term).
- Controlled Non-Static
 (pumping) groundwater
 level data helps determine
 hydraulic properties,
 boundaries, & response to
 stress.

Table 1. Typical length of water-level-data collection as a function of the intended use of the data

Intended use of water-level data		f data-collection e	, ,	
	Days/weeks	Months	Years	Decades
To determine the hydraulic properties of aquifers (aquifer tests)	~	 Image: A second s		
Mapping the altitude of the water able or potentiometric surface	~	1		
Monitoring short-term changes in ground-water recharge and storage	~	~	1	
Nonitoring long-term changes in pround-water recharge and storage			~	~
Vonitoring the effects of climatic variability			~	~
Monitoring regional effects of ground- vater development			~	~
Statistical analysis of water-level rends			~	~
Monitoring changes in ground-water low directions	-	~	~	~
Monitoring ground-water and surface-water interaction	~	~	~	~
Numerical (computer) modeling of ground-water flow or contaminant ransport	 Image: A second s	~	~	~
	EVE		Г	
V .	EXF Most applicable for intended use	Someti	mes applicable ended use	

Why Measure the Groundwater Level in a Well?

Groundwater Flow Directions (horizontal & vertical).

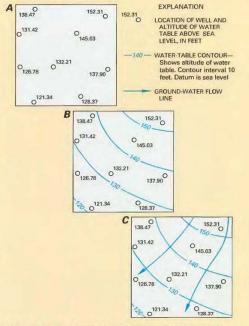
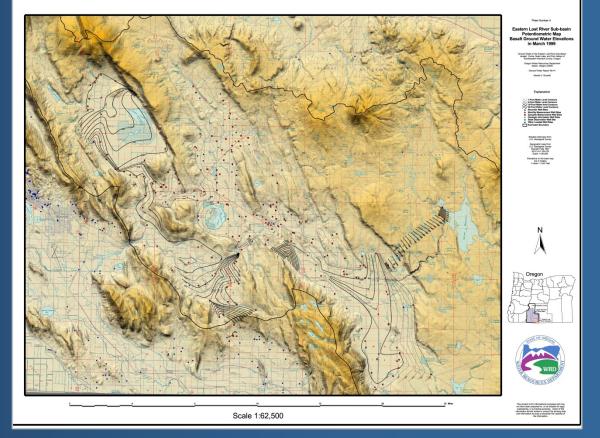


Figure A–2. Using known altitudes of the water table at individual wells (A), contour maps of the water-table surface can be drawn (B), and directions of ground-water flow along the water table can be determined (C) because flow usually is approximately perpendicular to the contours.

In addition to various practical uses of a water-table map, such as estimating an approximate depth for a proposed well, the configuration of the water table provides an indication of the approximate direction of ground-water flow at any location

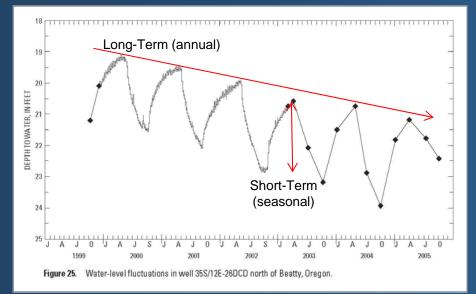
Source: USGS Circular 1139



Source: OWRD GW Report 41

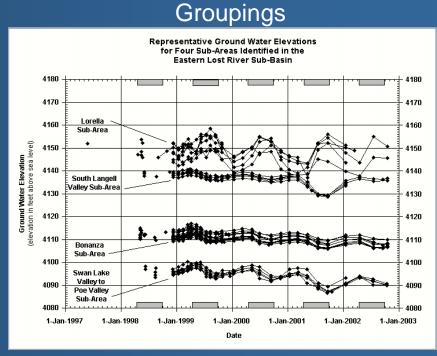
Why Measure the Groundwater Level in a Well?

Groundwater Level Trends (short & long-term) & Groupings



Trends

Source: USGS Scientific Investigations Report 2007-5050



Source: OWRD GW Report 41

Why Measure the Groundwater Level in a Well?

Groundwater Level Trends (shallow vs deep groundwater)

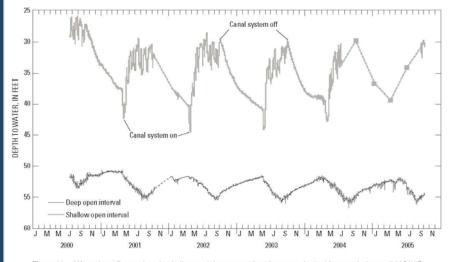


Figure 28. Water-level fluctuations in shallow and deep water-bearing zones in double-completion well 39S/12E-35ABB near Lorella, Oregon.

Source: USGS Scientific Investigations Report 2007-5050

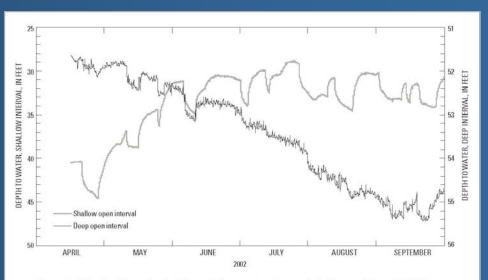
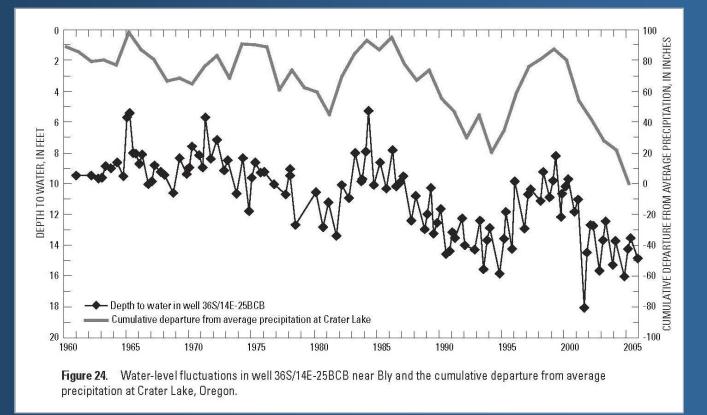


Figure 29. Water-level fluctuations in shallow and deep water-bearing zones in double-completion well 39S/12E-35ABB near Lorella, Oregon, with time scale expanded to show effects of nearby ground-water pumping.

Source: USGS Scientific Investigations Report 2007-5050

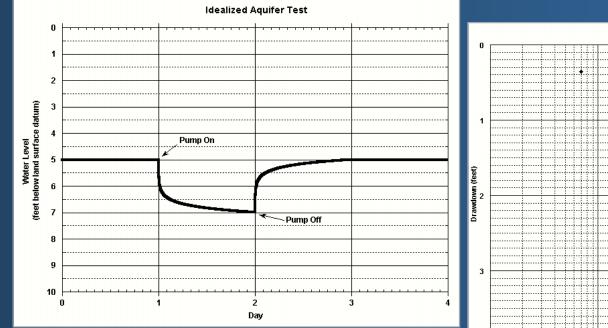
Why Measure the Groundwater Level in a Well?

Groundwater Level Trends (climate influence)

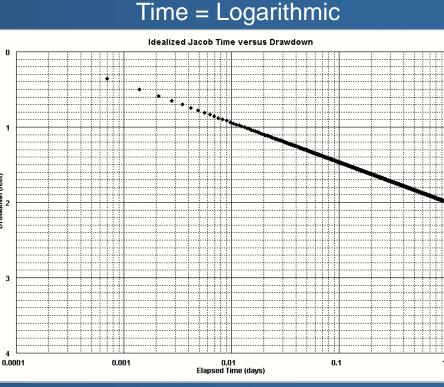


Why Measure the Groundwater Level in a Well?

Groundwater Response to Stress (pumping)



Time = Linear

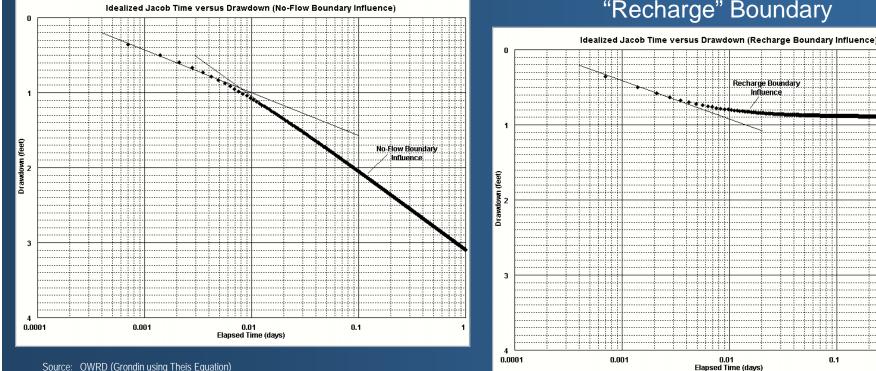


Source: OWRD (Grondin using Theis Equation)

Why Measure the Groundwater Level in a Well?

Groundwater Response to Stress (pumping & boundary influence)

"No-Flow" Boundary



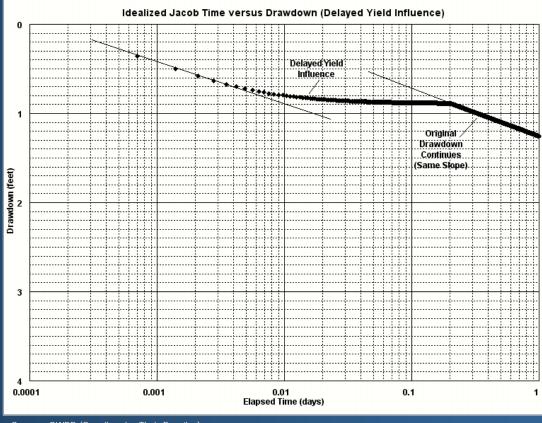
"Recharge" Boundary

0.1

Source: OWRD (Grondin using Theis Equation)

Why Measure the Groundwater Level in a Well?

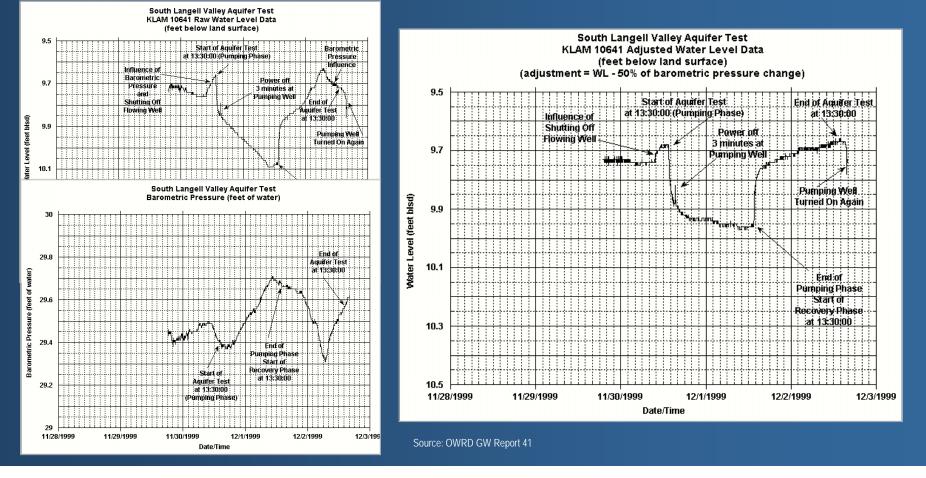
Groundwater Response to Stress (pumping & delayed yield)



Source: OWRD (Grondin using Theis Equation)

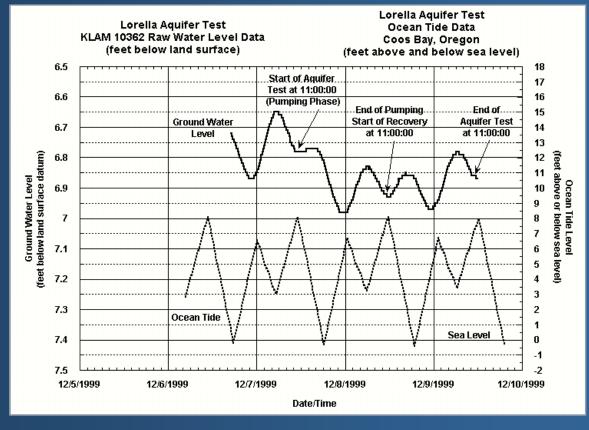
Why Measure the Groundwater Level in a Well?

Groundwater Response to Stress (pumping & barometric pressure)



Why Measure the Groundwater Level in a Well?

Groundwater Response to Stress (pumping & earth tide)



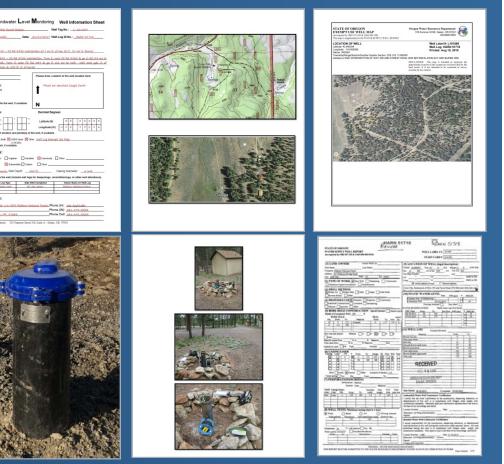
Source: OWRD GW Report 41

Well Documentation

Groundwater Data Analysis Needs Complete Well Documentation

Well Name:			w	ell Tag No	.:				
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Well Location:									
Well Address:									
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Township:	N or S								
Range:	E or W		1						
Section:									
Please enter the GPS	location for the well, if	available.	N						
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Address:			Pho	ne (W):					
City / State / Zip:			Pho	ne Cell:					

Source: OWRD Groundwater Section



Measurement Documentation

Groundwater Data Analysis Needs Complete Measurement Data

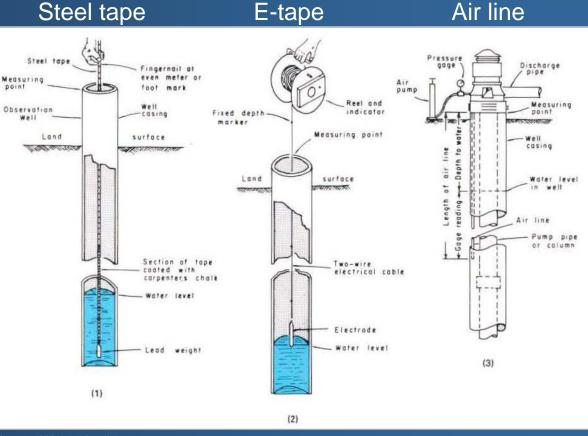
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Water Level Meters

Groundwater Level Measurement Methods (manual)

Manual measurement methods include graduated steel tape, air line, or electric tape (E-tape)

This instruction is for electric tape (E-tape, water level meter) only



Source: USGS Water Supply Paper 2220

Water Level Meters

Groundwater Level Measurement (Co-axial & Flat E-Tapes)

Co-axial E-Tape



Use in wells with narrow access, an installed pump, or possible obstructions Flat E-Tape



Use only in empty wells or wells with a dedicated measuring tube.

Water Level Meters

Groundwater Level Measurement (Co-axial E-Tape)



Copper weights secured to coaxial wire with rubber tubing



Co-axial wire



Water Level Meters

Groundwater Level Measurement (Co-axial & Flat E-Tapes)

COAXIAL WATER LEVEL METER



The coaxial water level meter has a thin line (like a speaker wire) marked in five-foot increments. Determining how much line you have in the well requires counting the color-coded markers using a pattern similar to adding with Roman numerals.

DEPTH (Feet)	COLOR-CODES FOR MARKERS
5	Pale Green/Orange/Pale Green
10	Pale Green
50	Red or Orange
100	Dark Green
500	Blue

FLAT-TAPE WATER LEVEL METER

The flat-tape water level meter usually has a 3/8-inch wide tape marked in engineering, standard, or metric scale. Determining how much tape you have in the well requires reading the tape (similar to reading a ruler).

Water Level Meters

Engineer's Tape Measure Used for Co-axial E-Tape Measurements

ENGINEER'S TAPE MEASURE



Co-axial e-tape measurements require the additional use of an engineer's tape measure to obtain measurements to the nearest 1/100th foot. The engineer's tape measure is marked in feet, 1/10th foot, 1/100th foot, and inches.

Well Measuring Points

Well Use Influences Well Measuring Points

Unused Wells





Submersible Pump





Turbine Pump



Well Measuring Points

Well Measuring Points Differ from Well to Well

Top of Casing





Even Top

Uneven Top



Well Measuring Points

Well Measuring Points Differ from Well to Well

Top of Well Cap Ring





Well Measuring Points

Well Measuring Points Differ from Well to Well

Top of Welded Plate





Well Measuring Points

Well Measuring Points Differ from Well to Well

Top of Well Seal





Access Port Hole

Bolt Hole



Well Measuring Points

Well Measuring Points Differ from Well to Well

Riser Pipe





Metal

PVC



Well Measuring Points

Well Measuring Points Differ from Well to Well

Pump Discharge Pipe Column



Remove Column Plug to Access Inside Column

Submersible Pump

Turbine Pump



Well Measuring Points

Well Measuring Points Differ from Well to Well

Angle Pipe





Into Casing Above Ground

Into Casing Below Ground



Well Measuring Points

Calculating Well Measuring Point "Height"

Top of Casing, Well Seal, or Metal Plate (above ground)

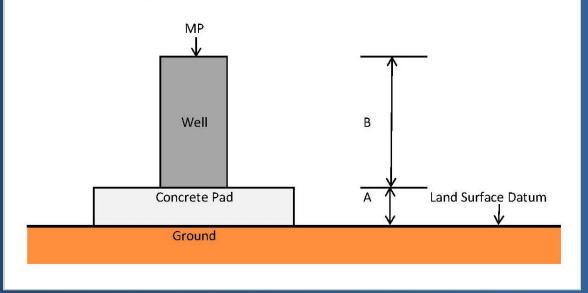
MP "Height" = A (feet above land surface datum: alsd) MP "Height" = a positive number Well A A A A Well Undisturbed Ground MP "Height" = a positive number

Well Measuring Points

Calculating Well Measuring Point "Height"

Top of Casing, Well Seal, or Metal Plate (above ground)

MP "Height" = A + B (feet above land surface datum: alsd) MP "Height" = a positive number

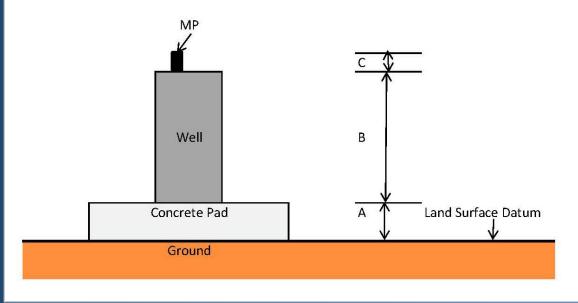


Well Measuring Points

Calculating Well Measuring Point "Height"

Top of Riser Pipe or Measure Tube (above ground)

MP "Height" = A + B + C (feet above land surface datum: alsd) MP "Height" = a positive number

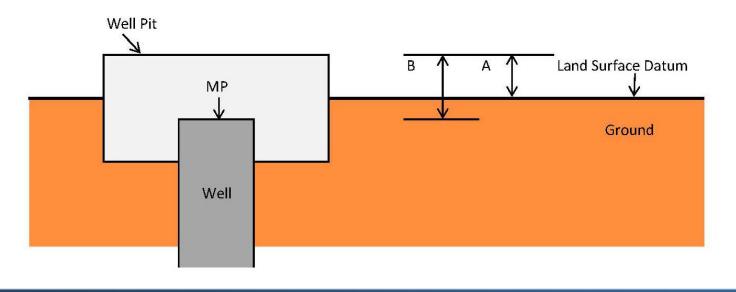


Well Measuring Points

Calculating Well Measuring Point "Height"

Top of Riser Pipe or Measure Tube (below ground)

MP "Height" = A - B (feet below land surface datum: blsd) MP "Height" = a negative number

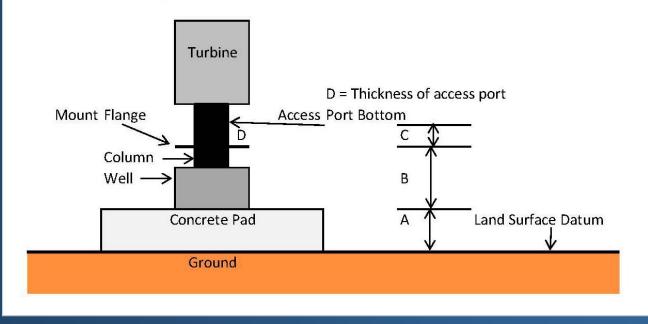


Well Measuring Points

Calculating Well Measuring Point "Height"

Horizontal Access Port in Vertical Discharge Column (above ground)

MP "Height" = A + B + C + D (feet above land surface datum: alsd) MP "Height" = a positive number



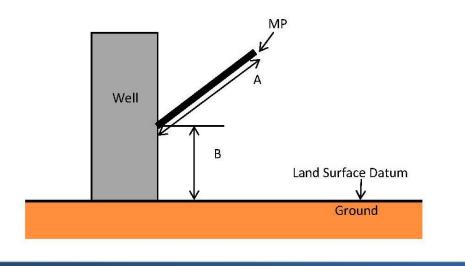
Well Measuring Points

Calculating Well Measuring Point "Height"

Angle Pipe (connection to well exposed above ground)

MP = lower lip of angle pipe mouth MP "Height" = A + B (feet above land surface datum: alsd) MP "Height" = a positive number

Measure "A" inside angle pipe from lower lip at casing to lower lip at mouth



Well Measuring Points

Calculating Well Measuring Point "Height"

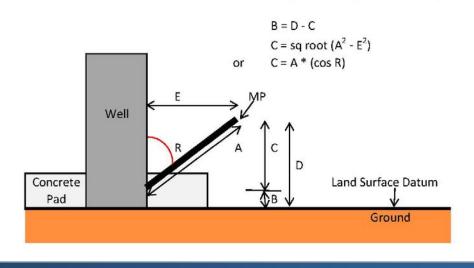
Angle Pipe (connection to well above ground but not exposed)

MP = lower lip of angle pipe mouth

MP "Height" = A + B (feet above land surface datum: alsd)

MP "Height" = a positive number

Measure "A" inside angle pipe from lower lip at casing to lower lip at mouth Note: "E" = horizontal distance from inside casing wall to angle pipe mouth (lower lip)



Well Measuring Points

Calculating Well Measuring Point "Height"

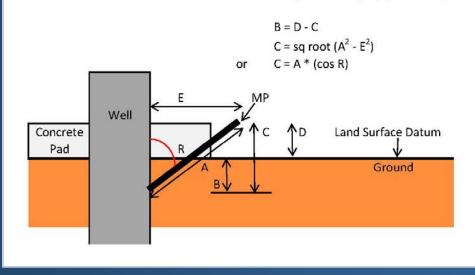
Angle Pipe (connection to well below ground, not exposed)

MP = lower lip of angle pipe mouth

MP "Height" = A + B (feet below land surface datum: blsd)

MP "Height" = a negative number

Measure "A" inside angle pipe from lower lip at casing to lower lip at mouth Note: "E" = horizontal distance from inside casing wall to angle pipe mouth (lower lip)



Water Level Measurement

Groundwater Level Measurement Goals

- 1. Measure at wells with well log(s) having construction & sub-surface geology data
- 2. Measure at wells with OWRD well ID tags (existing or project established)
- 3. Measure a static groundwater level (most useful measurement)
- 4. Measure to the nearest 1/100th foot to confirm measurement & static level
- 5. Measure 4 times minimum to confirm measurement & static level
- 6. Confirm measurement is a true groundwater level, not a false measurement
- 7. Document measurement completely on Water Level Data Sheet
- 8. Submit Water Level Data Sheet for QA/QC review and database entry
- 9. Keep a Water Level Data Sheet copy for own file

Water Level Measurement

Groundwater Level Measurement: Step by Step

- 1. Know the well being measured:
 - ✓ Its well log(s) having construction, sub-surface geology, & water level data
 - ✓ Its well identification (well tag) number
 - ✓ Its use: domestic, stock, irrigation, community, other
 - ✓ Its pump type and set-up
 - Its measuring point(s) & measuring point height(s)
 - ✓ Its previous groundwater level measurements (to assess this measurement)
 - ✓ Its previous hang-up, obstacle, sticking, & false reading issue history

Water Level Measurement

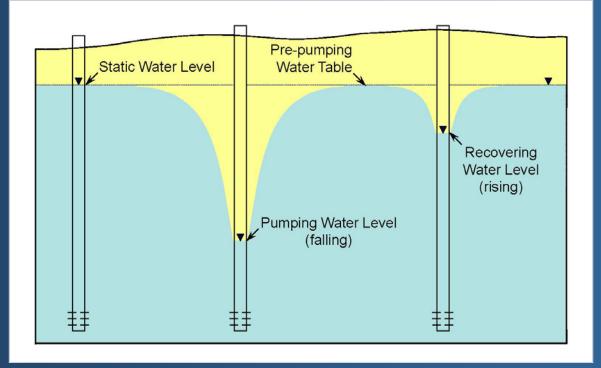
- Groundwater Level Measurement: Step by Step
 - 2. Bring the basic tools:
 - ✓ Co-axial e-tape, flat e-tape (bring at least 1 spare co-axial e-tape)
 - ✓ Engineer's tape measure with 1 ft., 1/10th ft., & 1/100th ft. increments
 - ✓ Bleach, water, & spray bottle for sanitizing equipment
 - Extra copper weights and rubber tubing for replacing e-tape weights
 - \checkmark Hand tools:
- Needle nose pliers
- Channel lock pliers
- Crescent wrenches
- Pipe wrench

- Hammer
- Lubricant: WD-40, other
- Flashlight & small mirror
- Teflon tape to wrap threads

Water Level Measurement

- Groundwater Level Measurement: Step by Step
 - 3. Turn off pump before measurement (prefer off 2 or more hours):

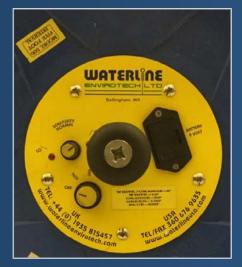
Goal = static (fully recovered) groundwater level



Water Level Measurement

Groundwater Level Measurement: Step by Step

- 4. Conduct the groundwater level measurement:
 - a. Test the water level meter (turn switch to test)
 - b. Turn water level meter switch to buzz
 - c. Turn sensitivity switch completely to the right
 - d. Slowly lower e-tape line down the well (no free fall)
 - e. Check feel of e-tape line with each lower (increasing weight)





Water Level Measurement

Groundwater Level Measurement: Step by Step

- 4. Conduct the groundwater level measurement (continued):
 - f. Lower line until meter indicates water or line becomes hung-up
 - If hung-up, line weight does not change, slowly raise the line 2 or more feet, bounce the line, and slowly lower again (repeat until line weight increases at and past hang-up depth
 - If the meter indicates water, be sure it is a real water level contact (steady buzz from that depth down), not cascading water, moisture on well or liner wall, or well equipment shorting the probe (unsteady buzz or buzz ends after that depth)
 - g. For a real water level contact:
 - Set the meter reel down
 - Grab the line at the measuring point
 - Measure water level & record on Water Level Data Sheet
 - Repeat measurement & recording data at 1-minute intervals 3 or more times to confirm static level (repeat more for falling or rising level)

Water Level Measurement

Groundwater Level Measurement: Step by Step (Flat E-Tape)

4. Conduct the groundwater level measurement (continued):

GW Level Below Land Surface = Hold + Cut – Tape Missing – MP "Height"

Flat E-tape with 1 ft., 1/10th ft., & 1/100th ft. markings

← Well

E -Tape Ree \rightarrow

Hold = actual hand hold spot at measuring point

Cut = 0.00 ft. for flat e-tape

Tape Missing = actual length of tape missing

Water Level Measurement

Groundwater Level Measurement: Step by Step (Co-Axial E-Tape)

4. Conduct the groundwater level measurement (continued):

GW Level Below Land Surface = Hold + Cut – Tape Missing – MP "Height"

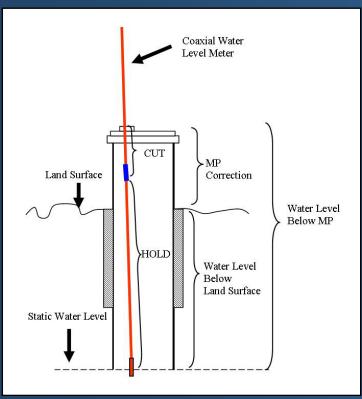
Co-axial E-tape with color coded markings every 5 ft.

Well Cut E -Tape Reel (1/100th ft.) Actual hand hold spot at measuring point Hold = color coded marking between well & actual hand hold Cut = distance from color marking to actual hand hold Tape Missing = actual length of tape missing

Water Level Measurement

Groundwater Level Measurement: Step by Step

4. Conduct the groundwater level measurement (continued):



Coaxial Meter

HOLD	270.00
CUT	+ 2.31
Water Level Below MP:	272.31
MP Correction:	<u>- 1.00</u>
Water Level BLS:	271.31

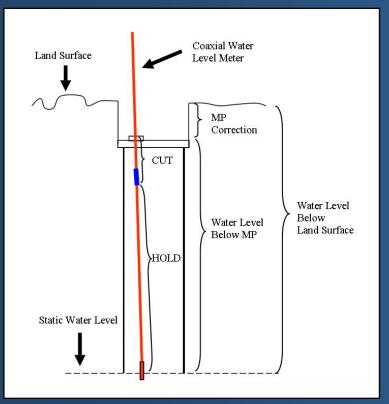
Flat-Tape Meter

Water Level Below MP:	272.31
MP Correction:	<u>- 1.00</u>
Water Level BLS:	271.31

Water Level Measurement

Groundwater Level Measurement: Step by Step

4. Conduct the groundwater level measurement (continued):



Coaxial Meter

HOLD	150.00
CUT	<u>+ 1.15</u>
Water Level Below MP:	151.15
MP Correction:	<u>+ 1.25</u>
Water Level BLS:	152.40

Flat-Tape Meter

Water Level Below MP:	151.15
MP Correction:	<u>+ 1.25</u>
Water Level BLS:	152.40

Water Level Measurement

- Groundwater Level Measurement: Step by Step
 - 4. Conduct the groundwater level measurement (continued):

ee Photo of Well
ee Proto of Well
Measured By
Jerry Grondi
↓

Water Level Measurement

- Groundwater Level Measurement: Step by Step
 - 4. Conduct the groundwater level measurement (continued):

Well Name/Owner USFS Crow					Guard Stat	ion				vve	ii Tag No	L-101589			
_		-				date if t			t changes.		Measuring	Point Sketch:			
	Month/ Day /Year						-	Description							
05	/05/20	16	+ 1.9	10 feet alsd	M	MP = top of casing on north side (pitless adapter cap removed)					Please see Photo of Wel				
* feet	above	(+) or be	elow (-) la	ind surface											
Wa	er Le	vels													
Mont	Day	Year	Time	HOLD	CUT	Tape	Water Level	MP	Water Level Below	Well	Pump Idle	Measured B			
		, our	(24 hr.)		(Coaxial Tape)	Missing (-)	Below MP (=)	Correction (+) or (-)	Land Surface (=)	Status*	Time				
12	09	2016	15:45	45.00	+ 2.35	- 0.00	47.35	-1.90	45.45		15 min	Jerry Gron			
12	09	2016	15:45 15:00	45.00	+ 2.35 + 2.25	- 0.00	47.3 <i>5</i> 47.2 <i>5</i>	-1.90 -1.90	45.45 45.35	R	15 min 30 min	Jerry Gron			
12	09	2016		45.00		- 0.00				R R		Jerry Gron			
12	09	2016	15:00	45.00	+ 2.25	- 0.00	47.2.5	-1.90	45.35		30 min	Jerry Gron			
12	09	2016	15:00 15:10	45.00	+ 2.2.5 + 2.20	- 0.00	47.25 47.20	-1.90 -1.90	45.35 45.30	R	30 min 40 min	Jerry Gron			
12	09	2016	15:00 15:10 15:15	45.00	+ 2.25 + 2.20 + 2.15	- 0.00	47.25 47.20 47.15	-1.90 -1.90 -1.90	45.35 45.30 45.25	R R	30 min 40 min 45 min	Jerry Gron.			
12	09	2016	15:00 15:10 15:15 15:20	45.00	+ 2.25 + 2.20 + 2.15 + 2.12	- 0.00	47.25 47.20 47.15 47.12	-1.90 -1.90 -1.90 -1.90	45.35 45.30 45.25 45.22	R R R	30 min 40 min 45 min 50 min	Jerry Gron			
12	09	2016	15:00 15:10 15:15 15:20 15:21	45.00	+ 2.25 + 2.20 + 2.15 + 2.12 + 2.11	- 0.00	47.25 47.20 47.15 47.12 47.11	-1.90 -1.90 -1.90 -1.90 -1.90	45.35 45.30 45.25 45.22 45.21	R R R R	30 min 40 min 45 min 50 min 51 min	Jerry Gron			
12		2016	15:00 15:10 15:15 15:20 15:21 15:22	45.00	+ 2.25 + 2.20 + 2.15 + 2.12 + 2.11 + 2.11		47.25 47.20 47.15 47.12 47.11 47.11	-1.90 -1.90 -1.90 -1.90 -1.90 -1.90	45.35 45.30 45.25 45.22 45.21 45.21	R R R R R	30 min 40 min 45 min 50 min 51 min 52 min	Jerry Grond			

ater level = rising 0.03 ft. per 5 min, well off a

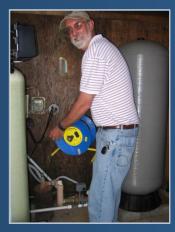
Status: S = Static, R = Rising, P = Pumping, F = Flowing, D = Falling

Water Level Measurement

Groundwater Level Measurement: Step by Step

- 4. Conduct the groundwater level measurement (continued):
 - h. Calculate depth to water below land surface on Water Level Data Sheet
 - i. Compare calculated depth to previous measurements for reasonableness
 - j. Slowly rewind e-tape line onto e-tape reel (can get stuck during rewind)
 - k. Turn water level meter off and sanitize it with diluted chlorine bleach
 - I. Secure well & measuring point

m. Turn pump on again if on before measurement

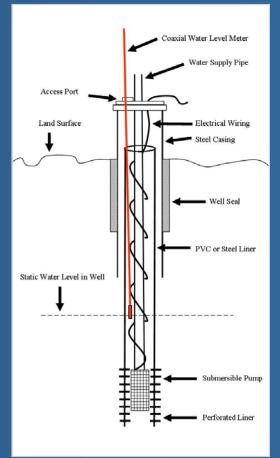




Water Level Measurement Challenges

- 1. Well Liner
 - a. Used to keep well borehole open
 - b. Made of PVC (often) or metal (less often)
 - c. Not always centered in the well
 - d. May be difficult to see
 - e. Moisture on liner side may cause e-tape to drag or stick





Water Level Measurement Challenges

- 2. Obstacles in Well
 - a. Wiring
 - b. Spacers
 - c. Top of Liner
 - d. Pump Equipment
 - e. Lost tools
 - f. Partial or complete collapse



Water Level Measurement Challenges

- 2. Obstacles in Well (continued): What to do when hung-up
 - a. Gently shake the line free (do not yank the line)
 - b. If unable to free line, pull line up slowly to release the attached line weights
 - Note the "hand-hold-point" if unable to free line or weights & strong pull is needed (strong pull may stretch the line)
 - d. Use back-up e-tape for additional measurements
 - e. Recalibrate e-tape line after strong pull and/or remove & discard affected section of e-tape line



Water Level Measurement Challenges

- 3. Cascading Water in Well
 - a. Sources
 - Perched water-bearing formation in open borehole
 - Leaky pump equipment
 - Damaged casing or liner
 - b. Can cause false reading
 - c. Water level meter signal may be steady or unsteady
 - d. May or may not be able to hear cascading water
 - e. Continue past cascading water to actual water level in the well

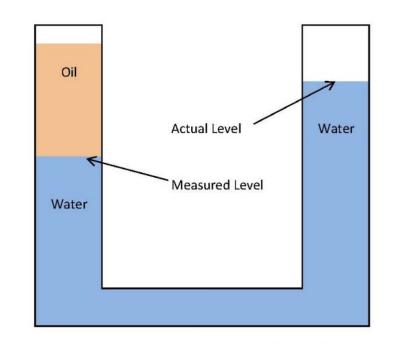




Water Level Measurement Challenges

Groundwater Level Measurement Challenges:

- 4. Oil Floating on Water in Well
 - a. Sources
 - Turbine lubricants
 - Accidental spill into well
 - b. Need to account for oil layer
 - Measured water level is below actual water level
 - Top of oil is above actual water level



Actual Level = Measured Level + (Oil Thickness x (oil density / water density))

Questions & Thank You



Photo by Chad Sobotka