

# Citizen Groundwater Level Monitoring

## Measuring Groundwater Levels in Wells

Oregon Water Resources Department



# Citizen Groundwater Level Monitoring

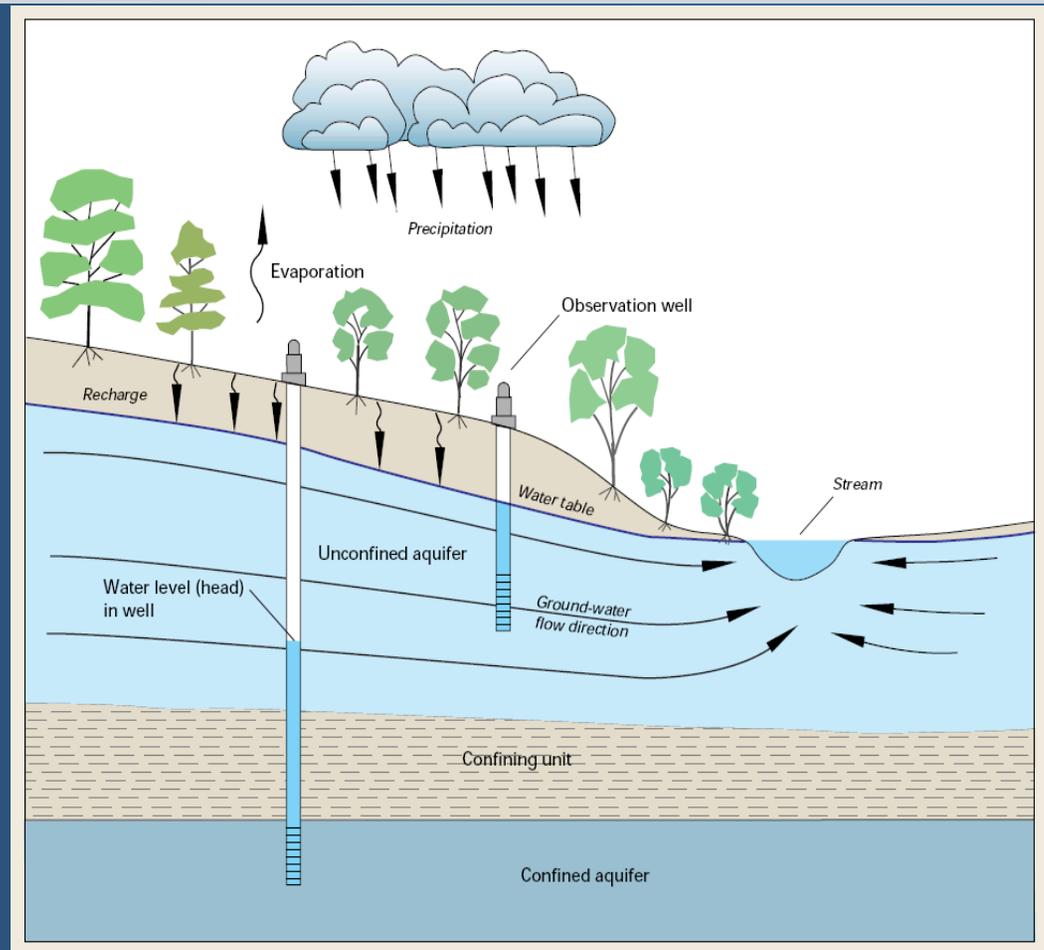
## Presentation Outline

- 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

# Citizen Groundwater Level Monitoring

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.



Source: USGS Circular 1217

# Citizen Groundwater Level Monitoring

## 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	Typical length of data-collection effort or hydrologic record required			
	Days/weeks	Months	Years	Decades
To determine the hydraulic properties of aquifers (aquifer tests)	✓	✓		
Mapping the altitude of the water table or potentiometric surface	✓	✓		
Monitoring short-term changes in ground-water recharge and storage	✓	✓	✓	
Monitoring long-term changes in ground-water recharge and storage			✓	✓
Monitoring the effects of climatic variability			✓	✓
Monitoring regional effects of ground-water development			✓	✓
Statistical analysis of water-level trends			✓	✓
Monitoring changes in ground-water flow directions	✓	✓	✓	✓
Monitoring ground-water and surface-water interaction	✓	✓	✓	✓
Numerical (computer) modeling of ground-water flow or contaminant transport	✓	✓	✓	✓

**EXPLANATION**



Most applicable for intended use

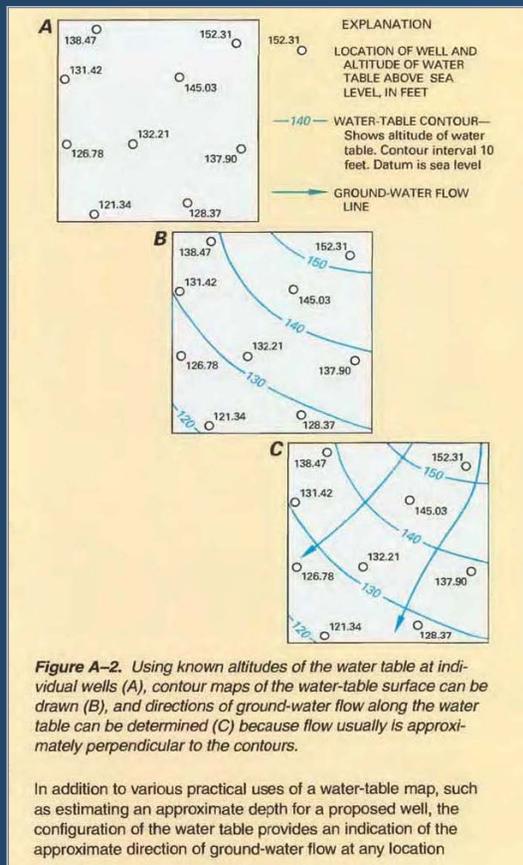


Sometimes applicable for intended use

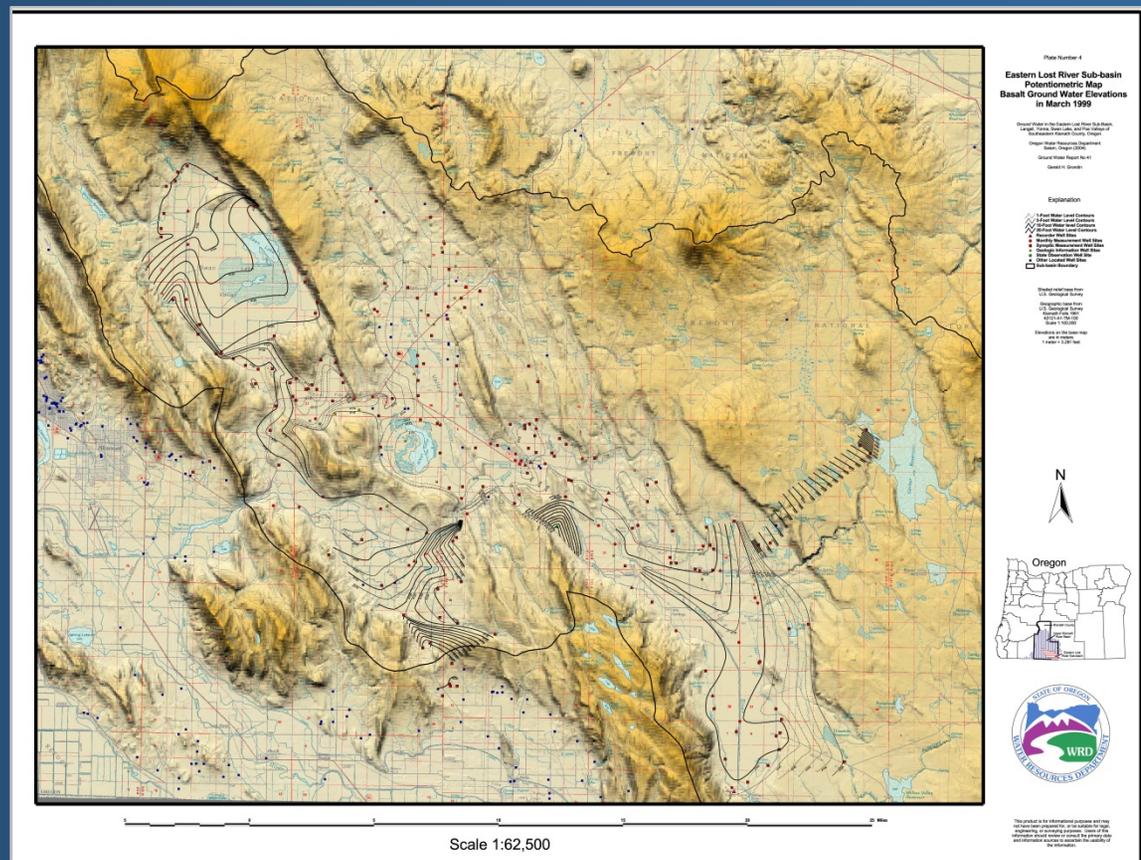
# Citizen Groundwater Level Monitoring

## Why Measure the Groundwater Level in a Well?

- Groundwater Flow Directions (horizontal & vertical).



Source: USGS Circular 1139

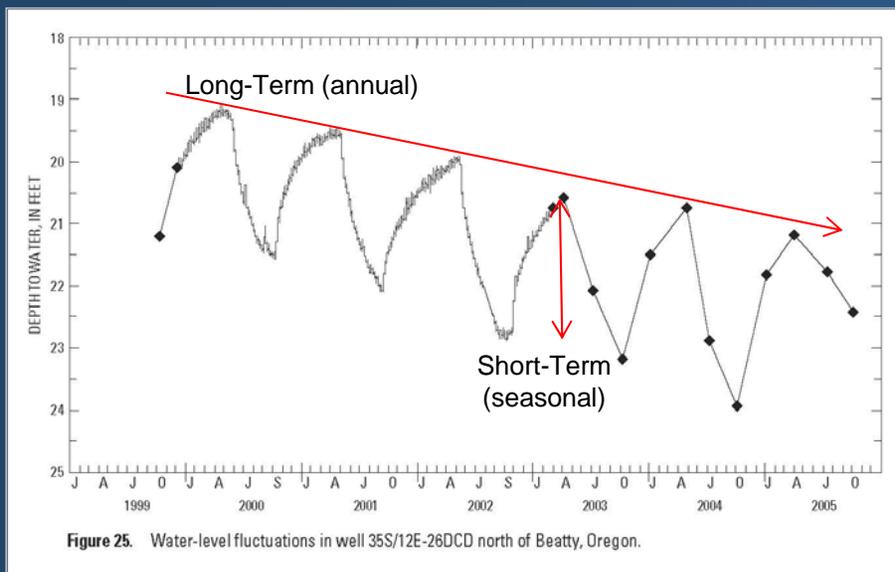


# Citizen Groundwater Level Monitoring

## Why Measure the Groundwater Level in a Well?

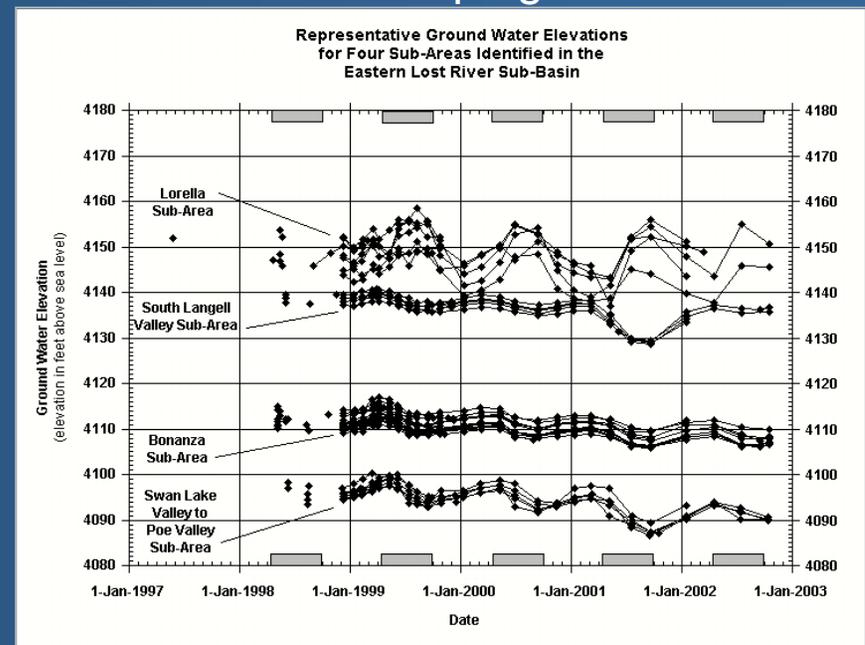
- Groundwater Level Trends (short & long-term) & Groupings

### Trends



Source: USGS Scientific Investigations Report 2007-5050

### Groupings

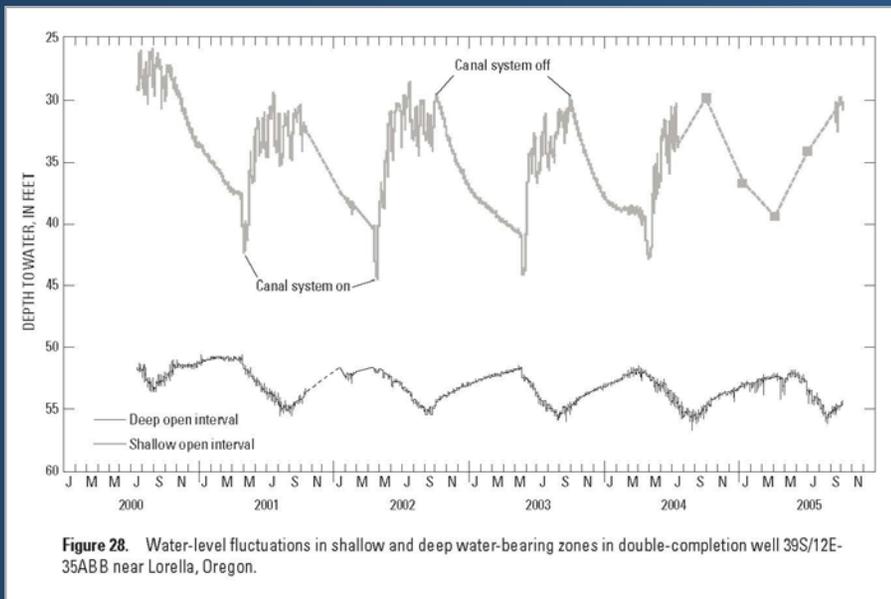


Source: OWRD GW Report 41

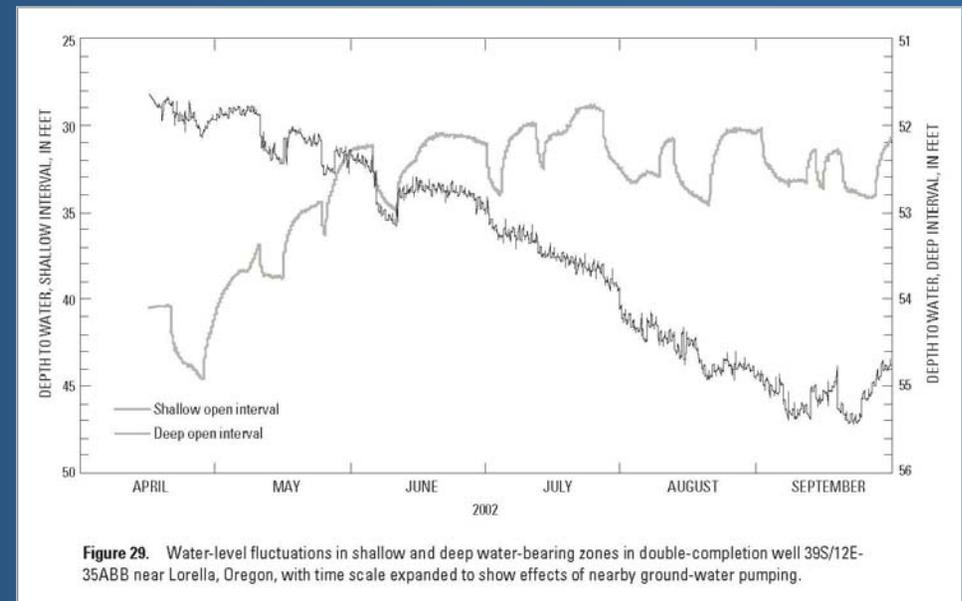
# Citizen Groundwater Level Monitoring

## Why Measure the Groundwater Level in a Well?

- Groundwater Level Trends (shallow vs deep groundwater)



Source: USGS Scientific Investigations Report 2007-5050

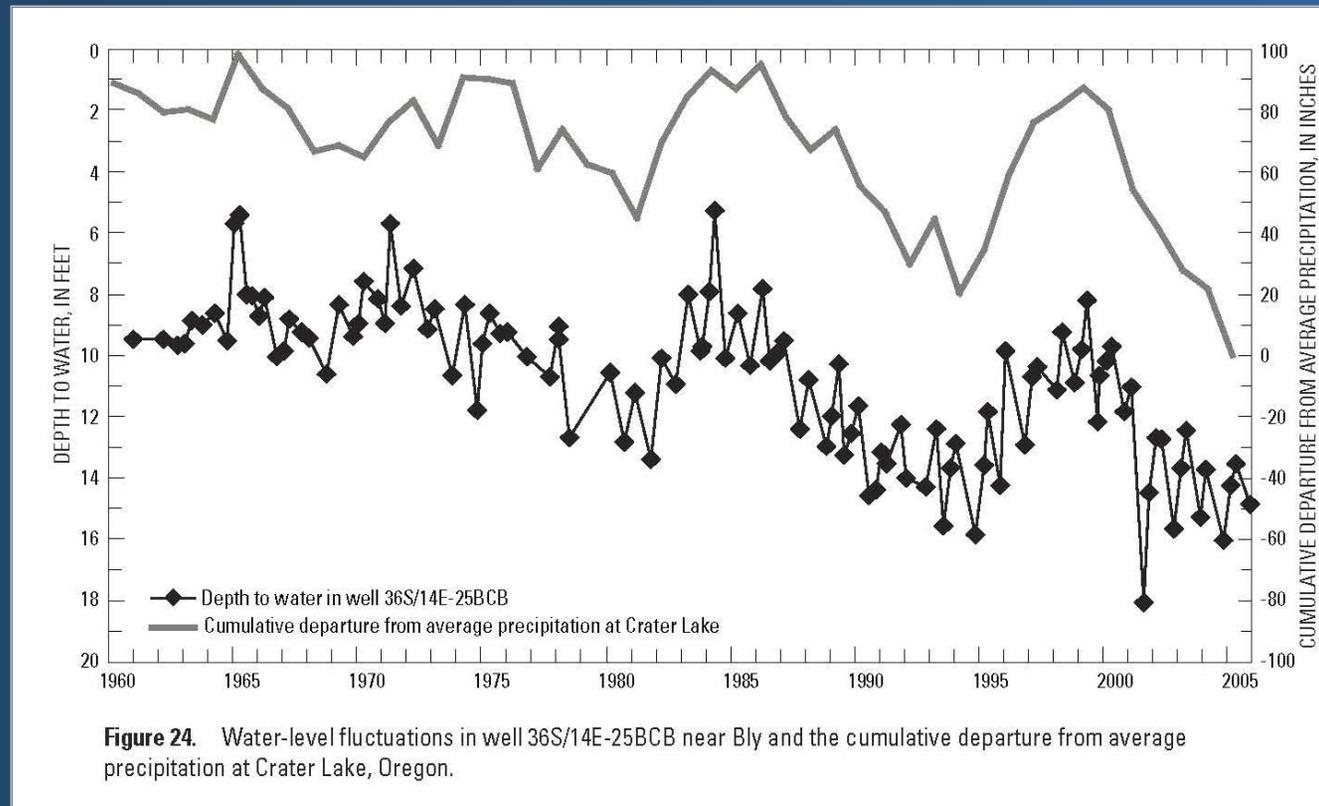


Source: USGS Scientific Investigations Report 2007-5050

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## Why Measure the Groundwater Level in a Well?

- Groundwater Level Trends (climate influence)

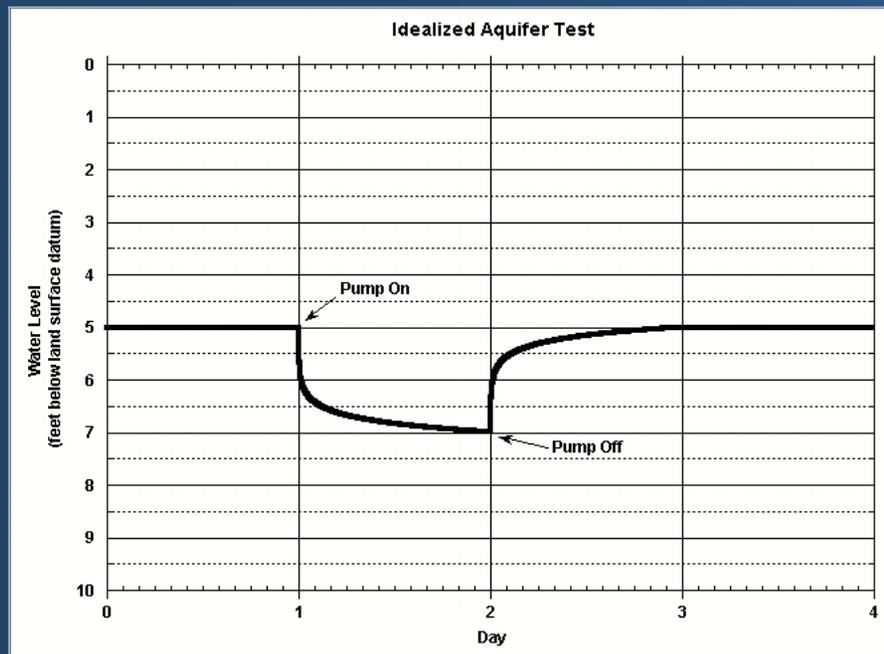


# Citizen Groundwater Level Monitoring

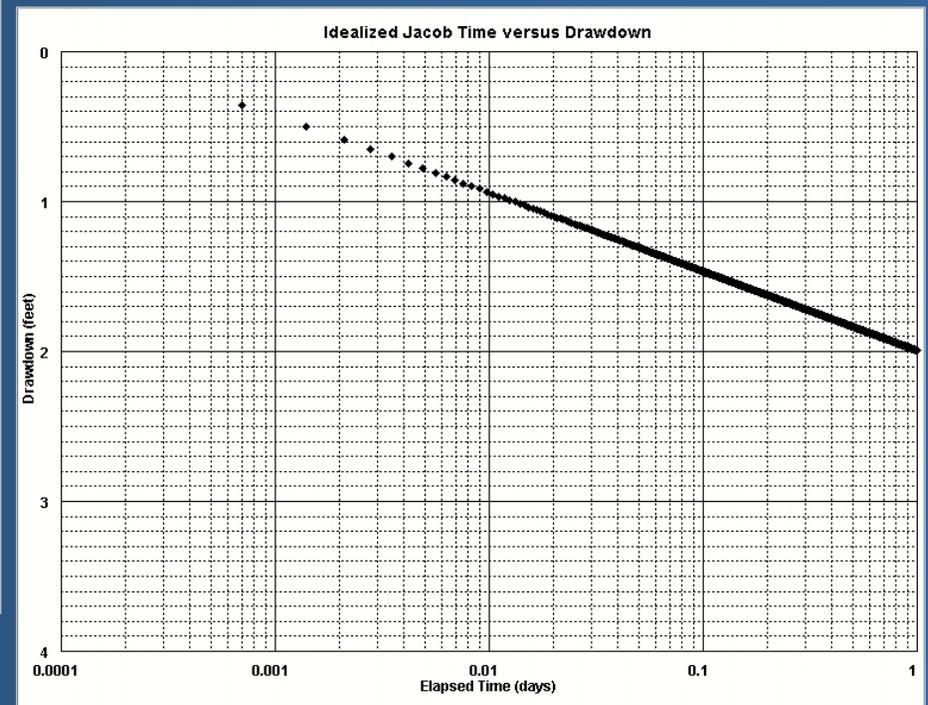
## Why Measure the Groundwater Level in a Well?

- Groundwater Response to Stress (pumping)

Time = Linear



Time = Logarithmic

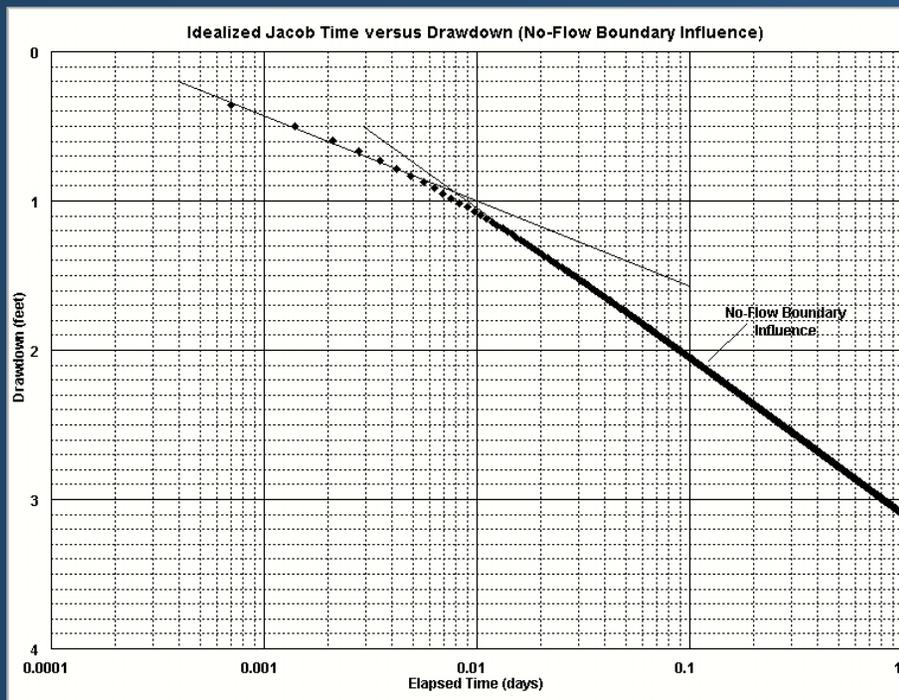


# Citizen Groundwater Level Monitoring

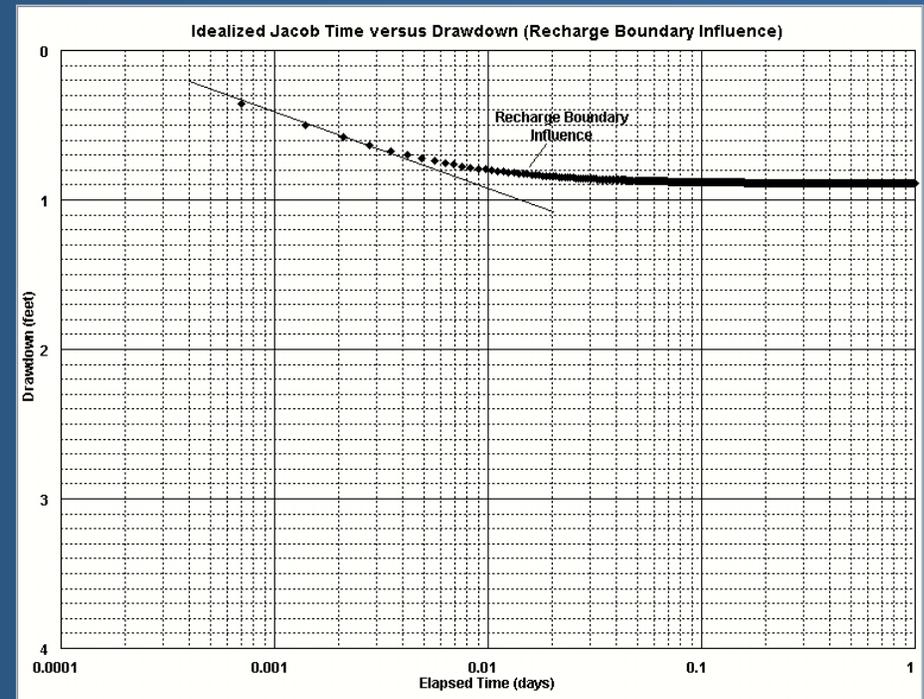
Why Measure the Groundwater Level in a Well?

- Groundwater Response to Stress (pumping & boundary influence)

“No-Flow” Boundary



“Recharge” Boundary

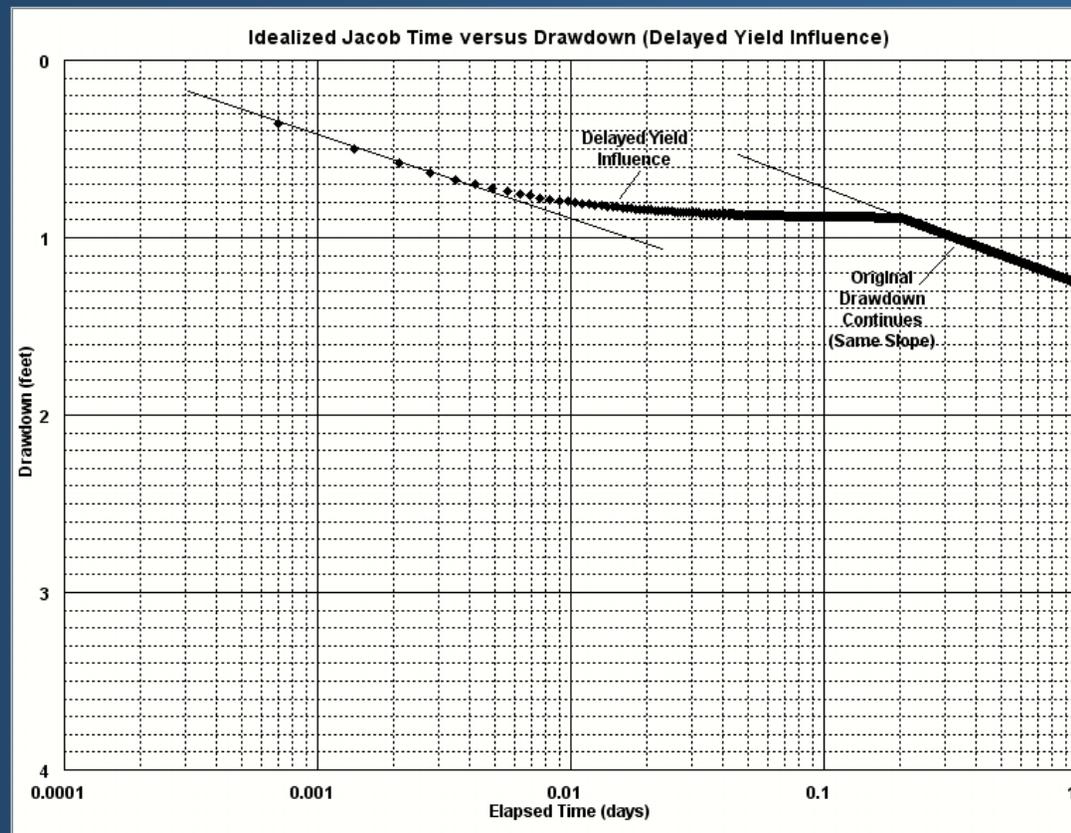


Source: OWRD (Gordin using Theis Equation)

# Citizen Groundwater Level Monitoring

Why Measure the Groundwater Level in a Well?

- Groundwater Response to Stress (pumping & delayed yield)

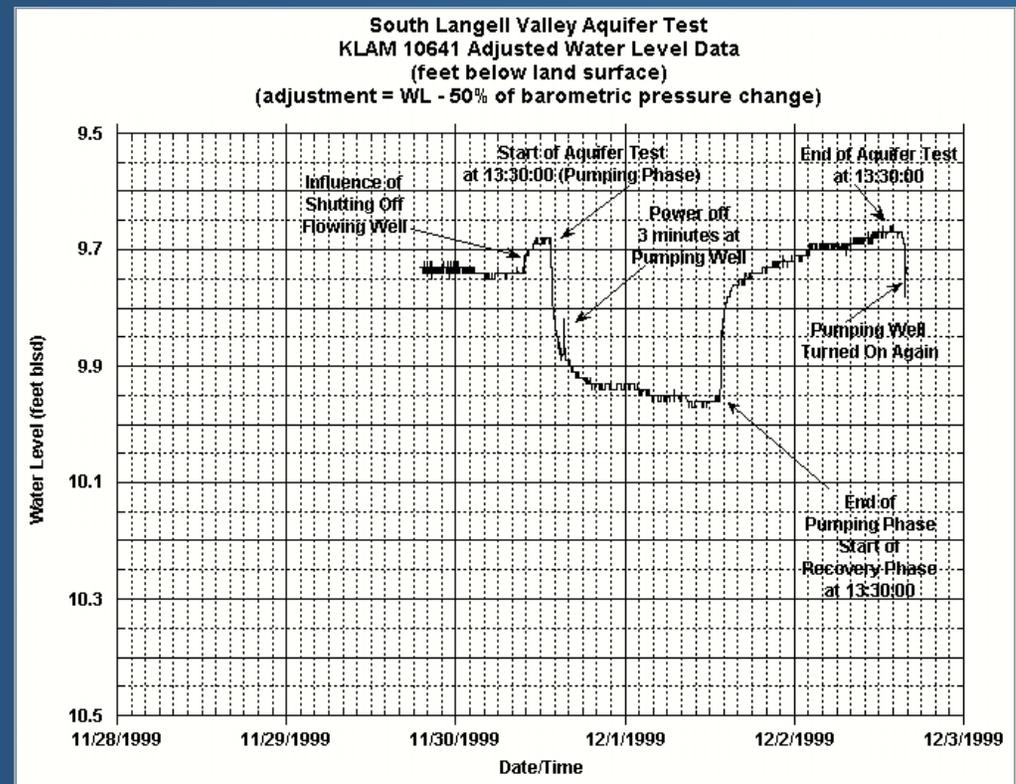
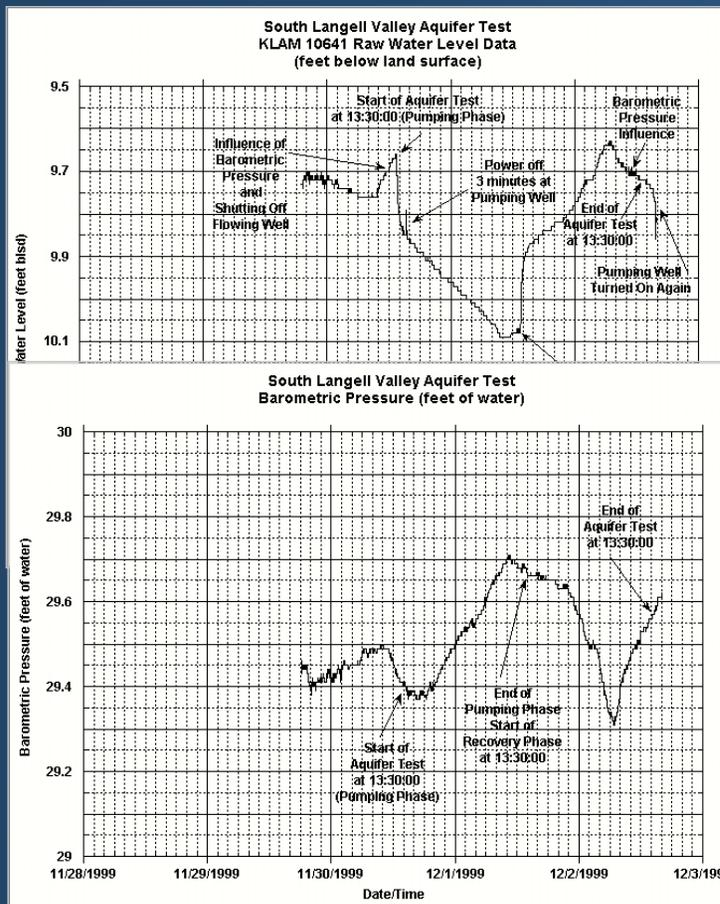


Source: OWRD (Grondin using Theis Equation)

# Citizen Groundwater Level Monitoring

## Why Measure the Groundwater Level in a Well?

- Groundwater Response to Stress (pumping & barometric pressure)

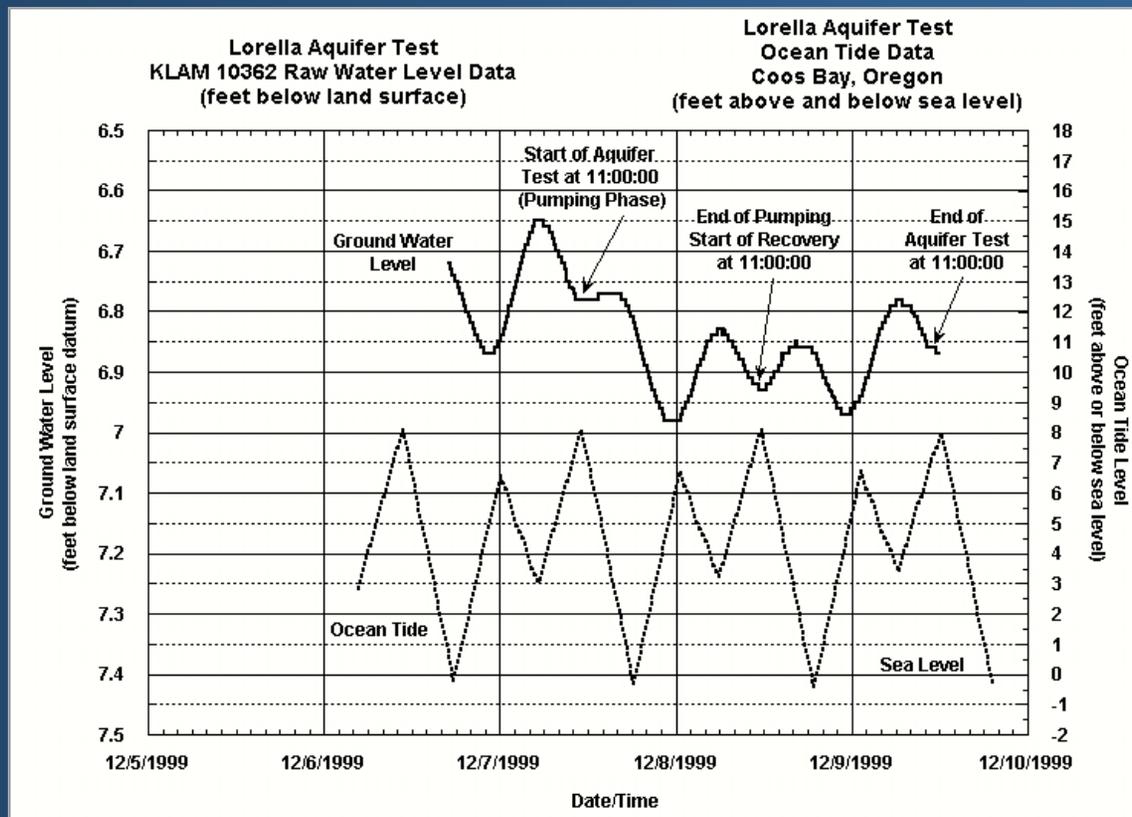


Source: OWRD GW Report 41

# Citizen Groundwater Level Monitoring

Why Measure the Groundwater Level in a Well?

- Groundwater Response to Stress (pumping & earth tide)







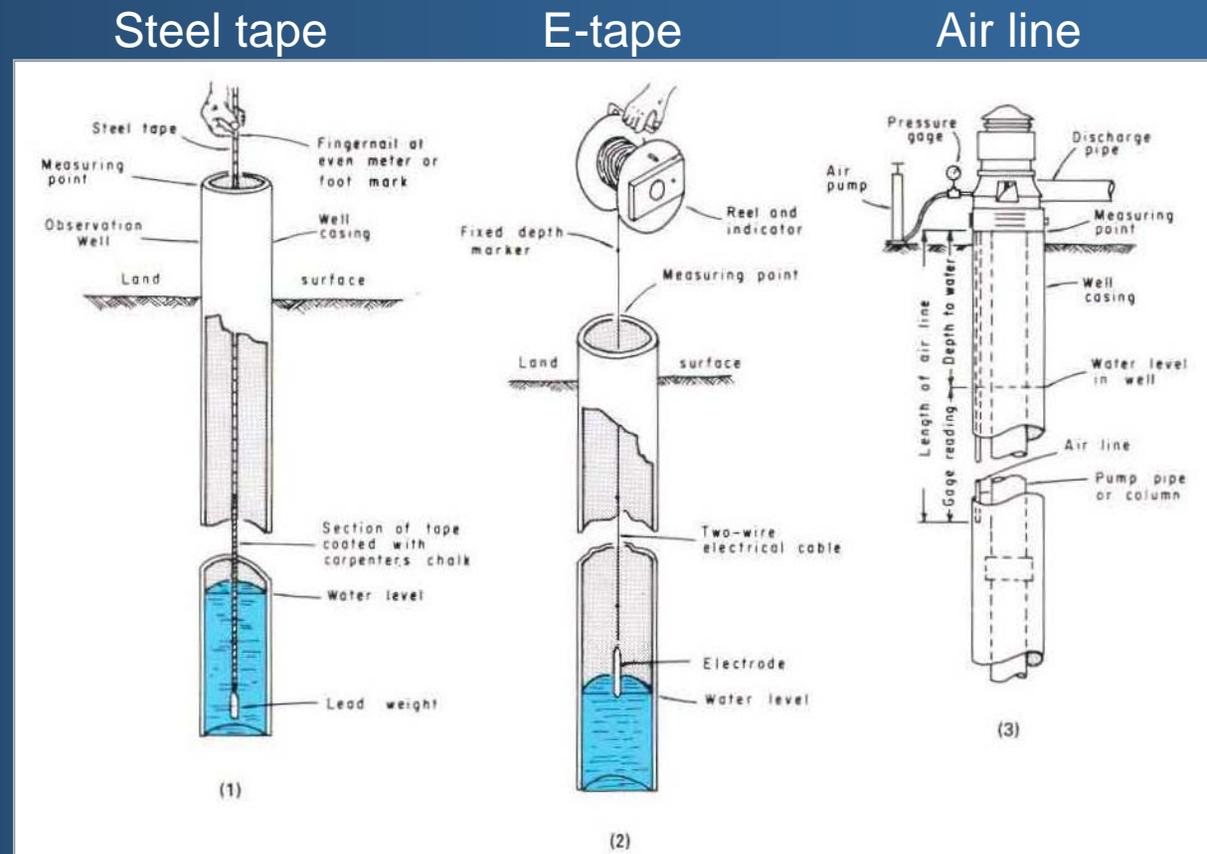
# Citizen Groundwater Level Monitoring

## 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

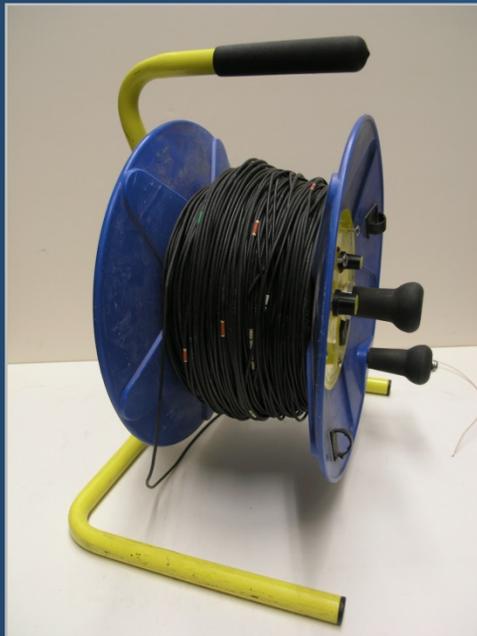


# Citizen Groundwater Level Monitoring

## 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.

# Citizen Groundwater Level Monitoring

## Water Level Meters

- Groundwater Level Measurement (Co-axial E-Tape)

Copper weights secured to co-axial wire with rubber tubing



Co-axial wire

Probe

# Citizen Groundwater Level Monitoring

## 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)

5

10

50

100

500

COLOR-CODES FOR MARKERS

Pale Green/Orange/Pale Green

Pale Green

Red or Orange

Dark Green

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).

# Citizen Groundwater Level Monitoring

## 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 1/100<sup>th</sup> foot. The engineer's tape measure is marked in feet, 1/10<sup>th</sup> foot, 1/100<sup>th</sup> foot, and inches.

# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Use Influences Well Measuring Points

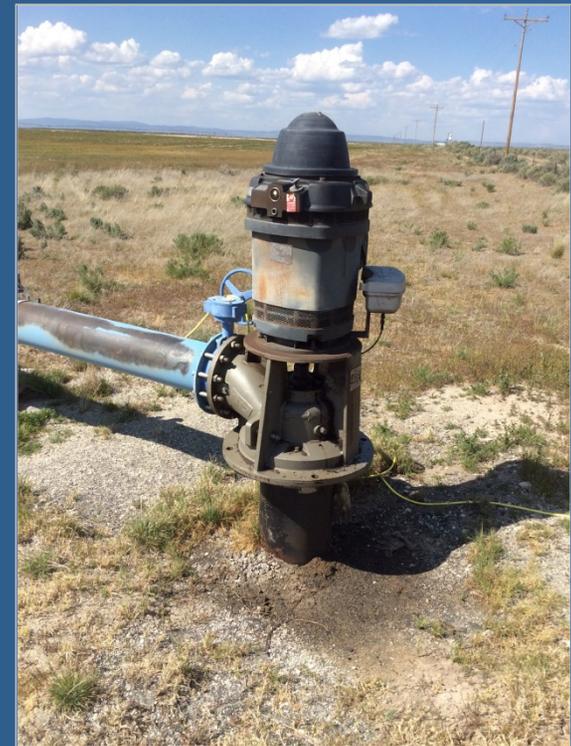
Unused Wells



Submersible Pump



Turbine Pump



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well  
Top of Casing



Even Top

Uneven Top



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well

Top of Well Cap Ring



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well

Top of Welded Plate



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well  
Top of Well Seal



Access Port Hole

Bolt Hole



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well  
Riser Pipe



Metal

PVC



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well  
Pump Discharge Pipe Column



Submersible Pump

Remove Column Plug to  
Access Inside Column



Turbine Pump

# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Well Measuring Points Differ from Well to Well

Angle Pipe



Into Casing  
Above Ground

Into Casing  
Below Ground

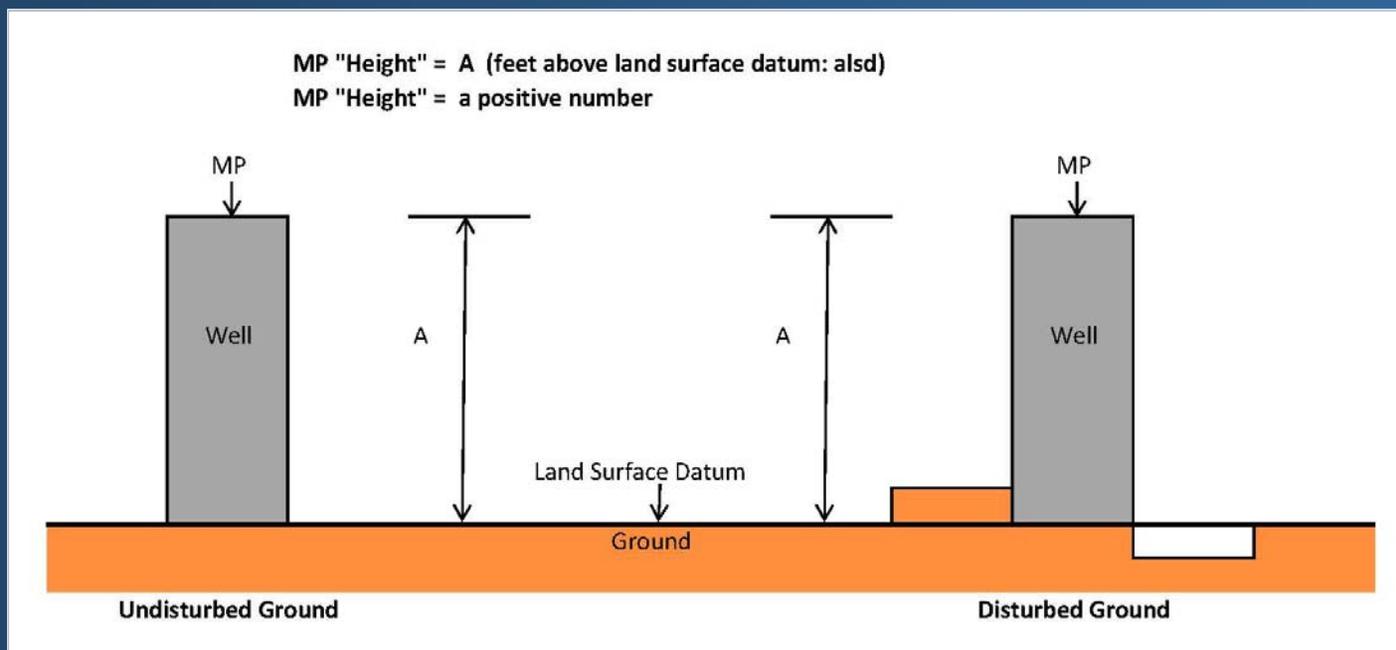


# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point “Height”

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

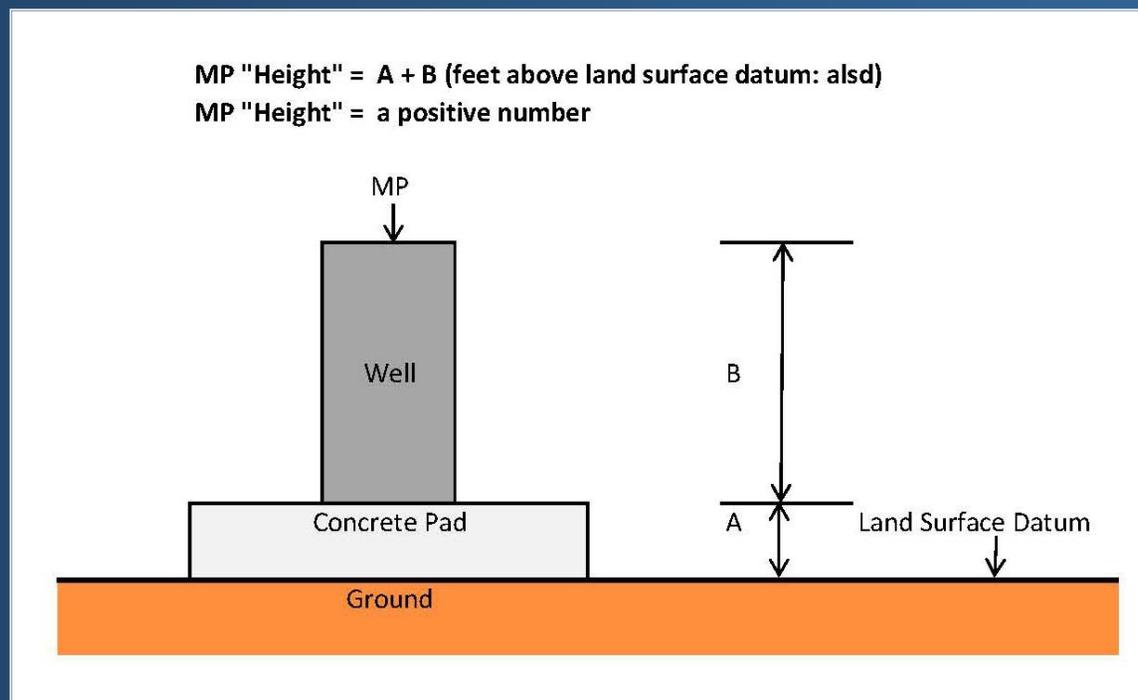


# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point “Height”

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

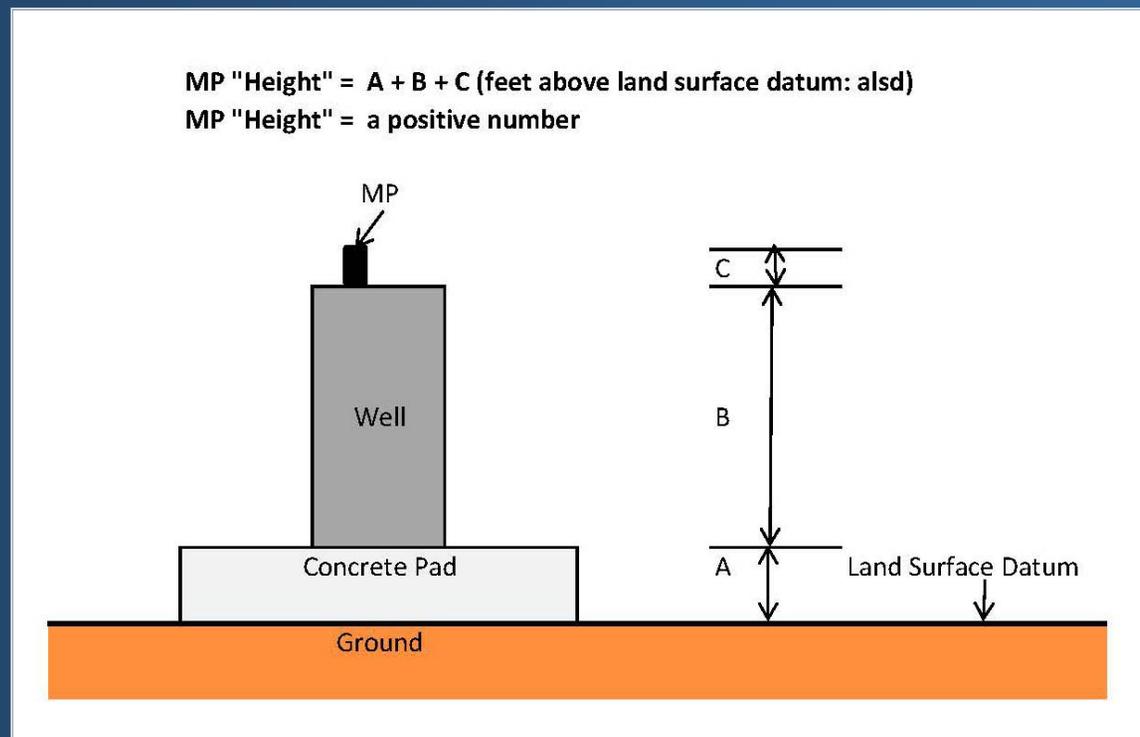


# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point "Height"

Top of Riser Pipe or Measure Tube (above ground)



# Citizen Groundwater Level Monitoring

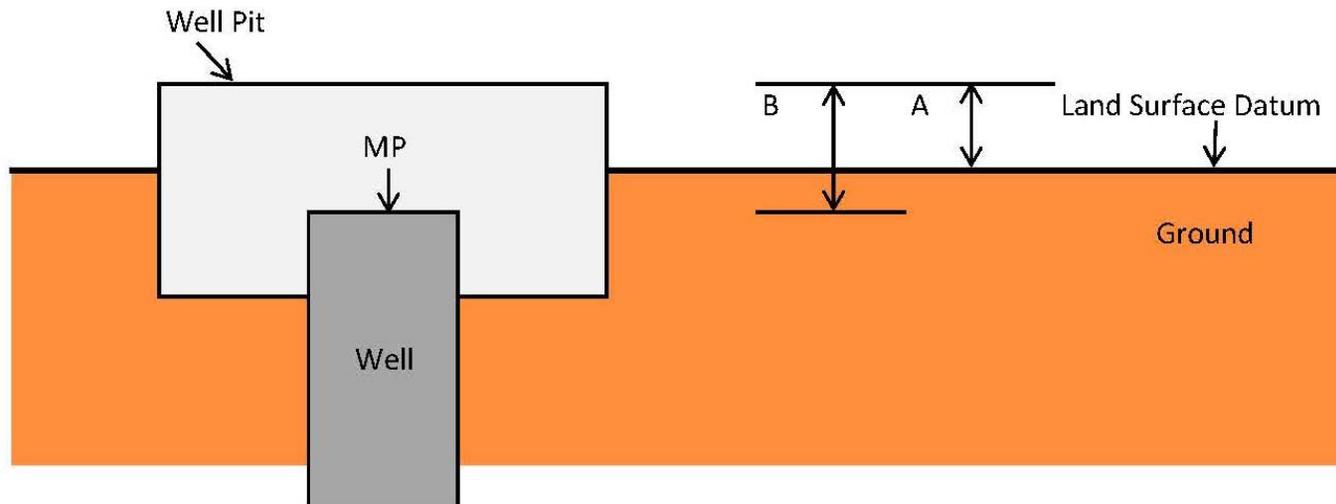
## Well Measuring Points

- 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

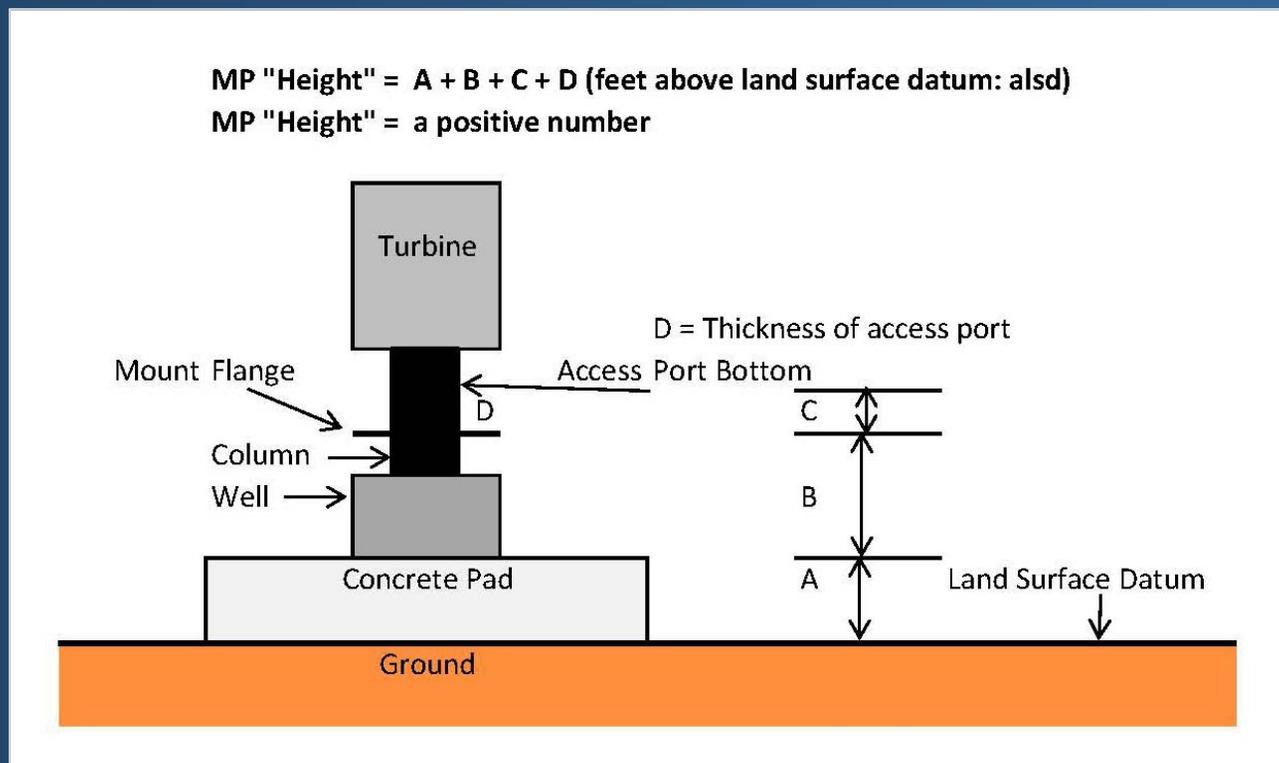


# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point "Height"

Horizontal Access Port in Vertical Discharge Column (above ground)



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point "Height"

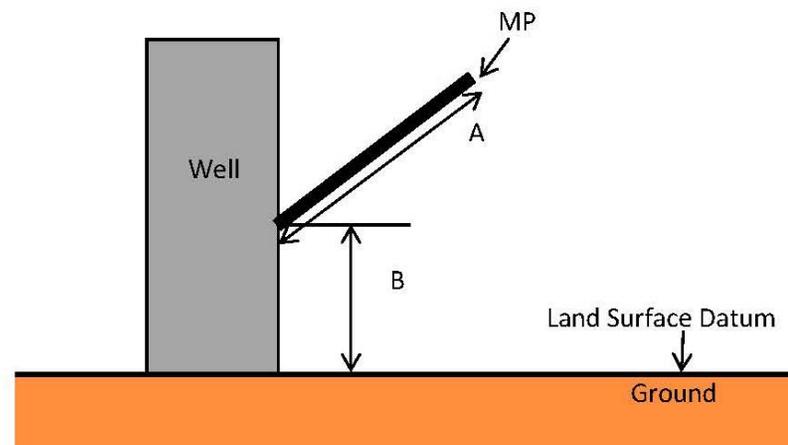
Angle Pipe (connection to well exposed above ground)

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



# Citizen Groundwater Level Monitoring

## Well Measuring Points

- Calculating Well Measuring Point "Height"

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

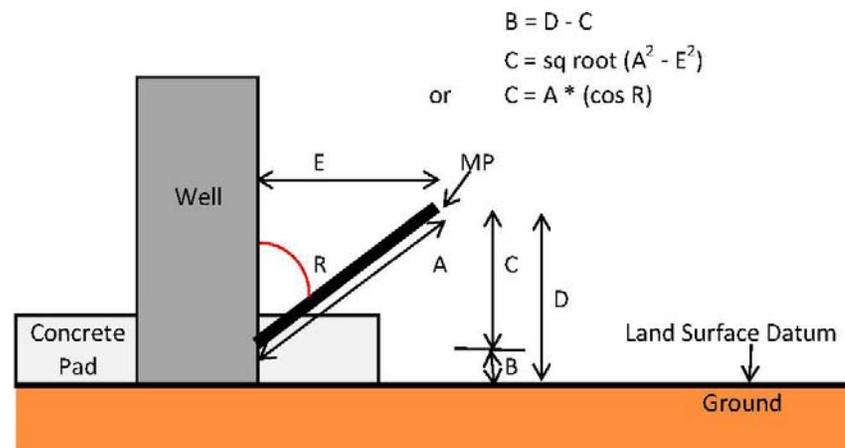
MP = lower lip of angle pipe mouth

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)



# Citizen Groundwater Level Monitoring

## 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

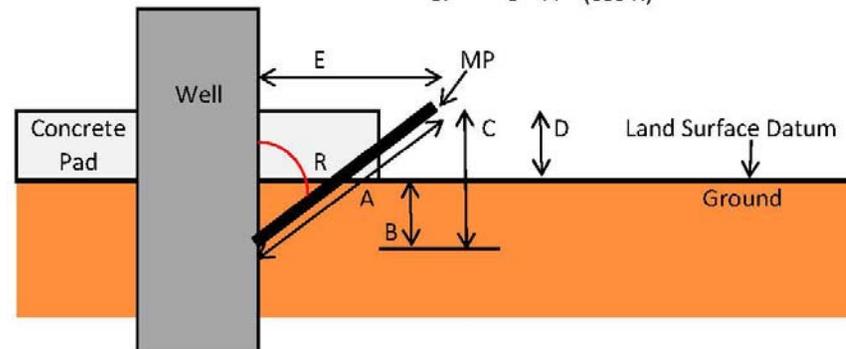
Measure "A" inside angle pipe from lower lip at casing to lower lip at mouth

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

$$B = D - C$$

$$C = \text{sq root } (A^2 - E^2)$$

or  $C = A * (\cos R)$



# Citizen Groundwater Level Monitoring

## 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 1/100<sup>th</sup> 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

# Citizen Groundwater Level Monitoring

## 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

# Citizen Groundwater Level Monitoring

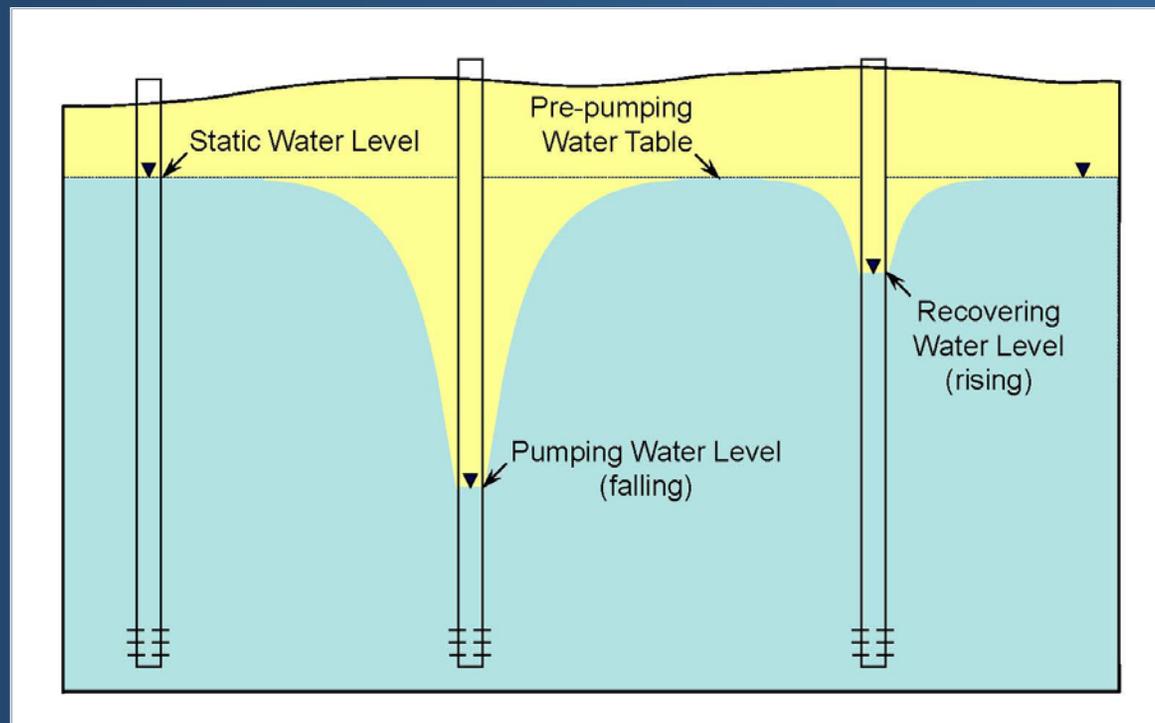
## Water Level Measurement

- 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., 1/10<sup>th</sup> ft., & 1/100<sup>th</sup> ft. increments
    - ✓ Bleach, water, & spray bottle for sanitizing equipment
    - ✓ Extra copper weights and rubber tubing for replacing e-tape weights
    - ✓ 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

# Citizen Groundwater Level Monitoring

## Water Level Measurement

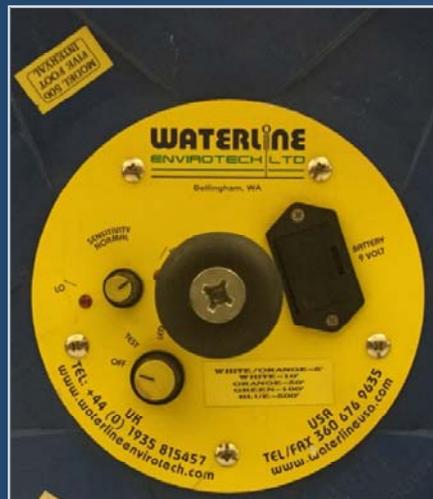
- Groundwater Level Measurement: Step by Step
  3. Turn off pump before measurement (prefer off 2 or more hours):  
Goal = static (fully recovered) groundwater level



# Citizen Groundwater Level Monitoring

## 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)



# Citizen Groundwater Level Monitoring

## 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)

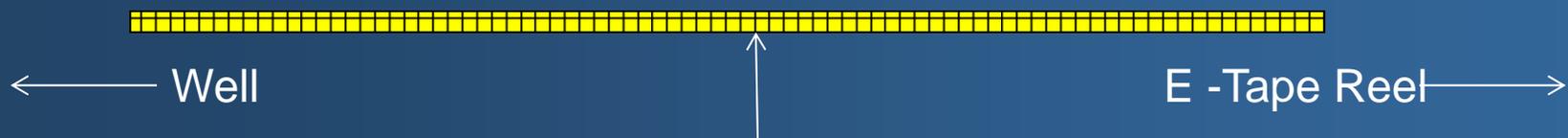
# Citizen Groundwater Level Monitoring

## Water Level Measurement

- Groundwater Level Measurement: Step by Step (Flat E-Tape)
  - Conduct the groundwater level measurement (continued):

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

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



Hold = actual hand hold spot at measuring point

Cut = 0.00 ft. for flat e-tape

Tape Missing = actual length of tape missing

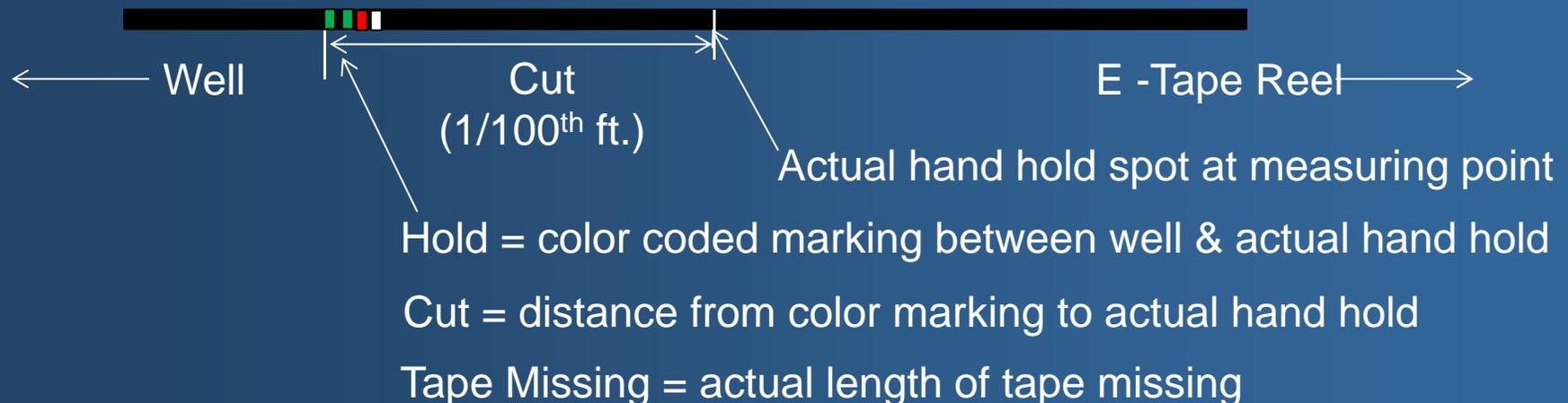
# Citizen Groundwater Level Monitoring

## Water Level Measurement

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

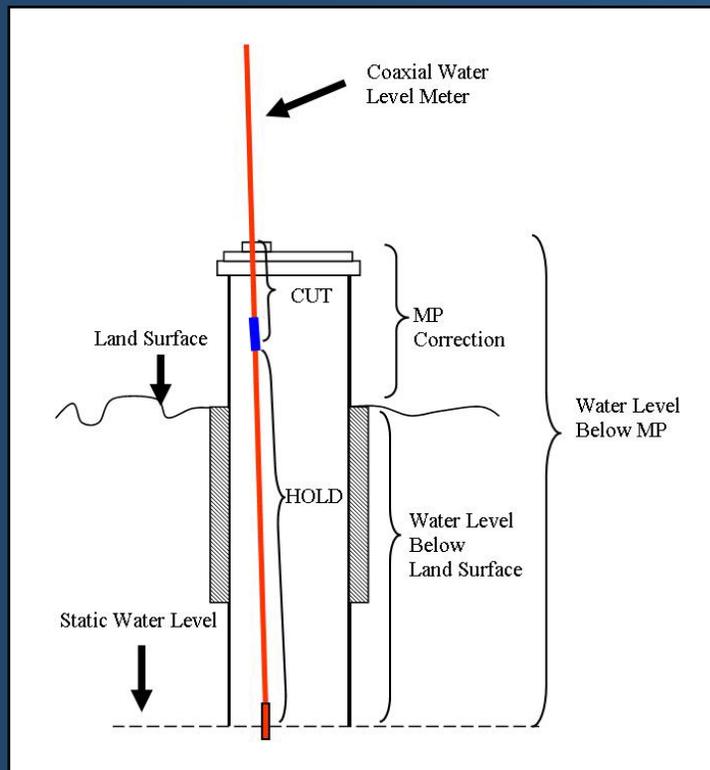


# Citizen Groundwater Level Monitoring

## Water Level Measurement

### ■ Groundwater Level Measurement: Step by Step

#### 4. Conduct the groundwater level measurement (continued):



### Coaxial Meter

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

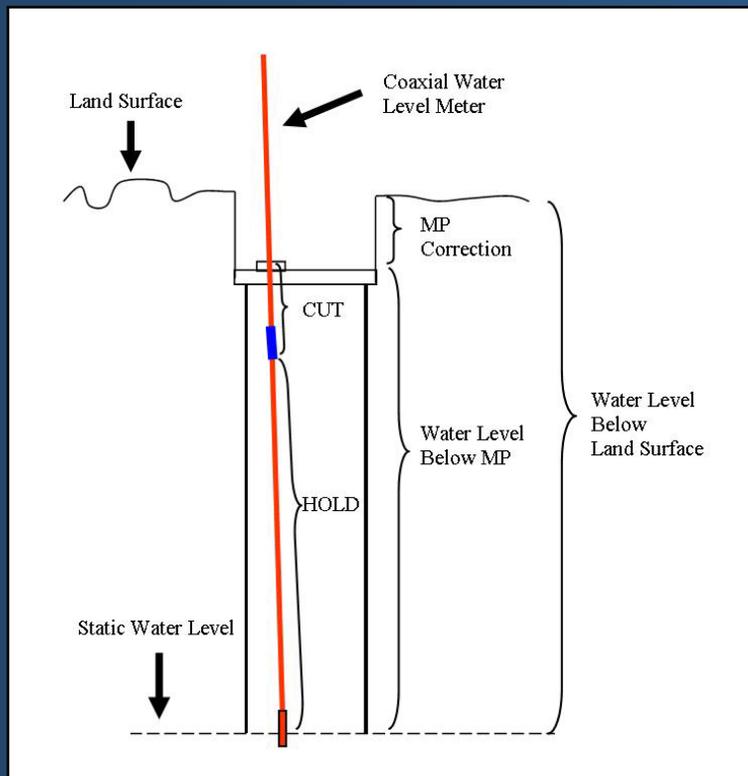
### Flat-Tape Meter

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

# Citizen Groundwater Level Monitoring

## Water Level Measurement

- Groundwater Level Measurement: Step by Step
  - 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

# Citizen Groundwater Level Monitoring

## Water Level Measurement

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

**Community Groundwater Level Monitoring**

Well Name/Owner USFS Crow Flat Guard Station

**Measuring Points (MP):** Please update if the measuring point changes.

Month/Day/Year	feet +/- land surface*	Description
05/05/2016	+ 1.90 feet alsd	MP = top of casing on north side (pitless adapter cap removed)

\* feet above (+) or below (-) land surface.

**Water Level Data Sheet**  
(Use single sheet per well visit)

Well Tag No. L-102589

Measuring Point Sketch:

Please see Photo of Well

**Water Levels:**

Month	Day	Year	Time (24 hr.)	HOLD (Coaxial Tape)	CUT (Coaxial Tape)	Tape Missing (-)	Water Level Below MP (=)	MP Correction (+) or (-)	Water Level Below Land Surface (=)	Well Status*	Pump Idle Time	Measured By:
11	02	2016	10:46	45.00	+ 3.35	- 0.00	48.35	-1.90	46.45		days	Jerry Grondin
↓	↓	↓	10:47	↓	+ 3.35	↓	48.35	-1.90	46.45		↓	↓
↓	↓	↓	10:48	↓	+ 3.35	↓	48.35	-1.90	46.45		↓	↓
↓	↓	↓	10:49	↓	+ 3.35	↓	48.35	-1.90	46.45	S	↓	↓

Water Level Comments: (Please note the date and any conditions that affected the water level measurements.)

Measure device = E-Tape = GHG #3  
Water level = static, well off for days. Water level = 0.02 ft. down from 5 May 2016

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

# Citizen Groundwater Level Monitoring

## Water Level Measurement

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

**Community Groundwater Level Monitoring**

Well Name/Owner USFS Crow Flat Guard Station

**Measuring Points (MP):** Please update if the measuring point changes.

Month/Day/Year	feet +/- land surface*	Description
05/05/2016	+ 1.90 feet old	MP = top of casing on north side (pitless adapter cap removed)

\* feet above (+) or below (-) land surface.

**Water Level Data Sheet**  
(Use single sheet per well visit)

Well Tag No. L-101589

Measuring Point Sketch:

Please see Photo of Well

**Water Levels:**

Month	Day	Year	Time (24 hr.)	HOLD (Coaxial Tape)	CUT (Coaxial Tape)	Tape Missing (-)	Water Level Below MP (")	MP Correction (+) or (-)	Water Level Below Land Surface (")	Well Status*	Pump Idle Time	Measured By:
12	09	2016	15:45	45.00	+ 2.35	- 0.00	47.35	-1.90	45.45		15 min	Jerry Grondin
			15:00		+ 2.25		47.25	-1.90	45.35	R	30 min	
			15:10		+ 2.20		47.20	-1.90	45.30	R	40 min	
			15:15		+ 2.15		47.15	-1.90	45.25	R	45 min	
			15:20		+ 2.12		47.12	-1.90	45.22	R	50 min	
			15:21		+ 2.11		47.11	-1.90	45.21	R	51 min	
			15:22		+ 2.11		47.11	-1.90	45.21	R	52 min	
			15:23		+ 2.10		47.10	-1.90	45.20	R	53 min	
			15:24		+ 2.10		47.10	-1.90	45.20	R	54 min	
			15:25		+ 2.09		47.09	-1.90	45.19	R	55 min	

**Water Level Comments:** (Please note the date and any conditions that affected the water level measurements.)

Measure device = E-Tape = GHG #3  
 Water level = rising 0.03 ft. per 5 min., well off at 15:30.

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

# Citizen Groundwater Level Monitoring

## 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
    - l. Secure well & measuring point
    - m. Turn pump on again if on before measurement



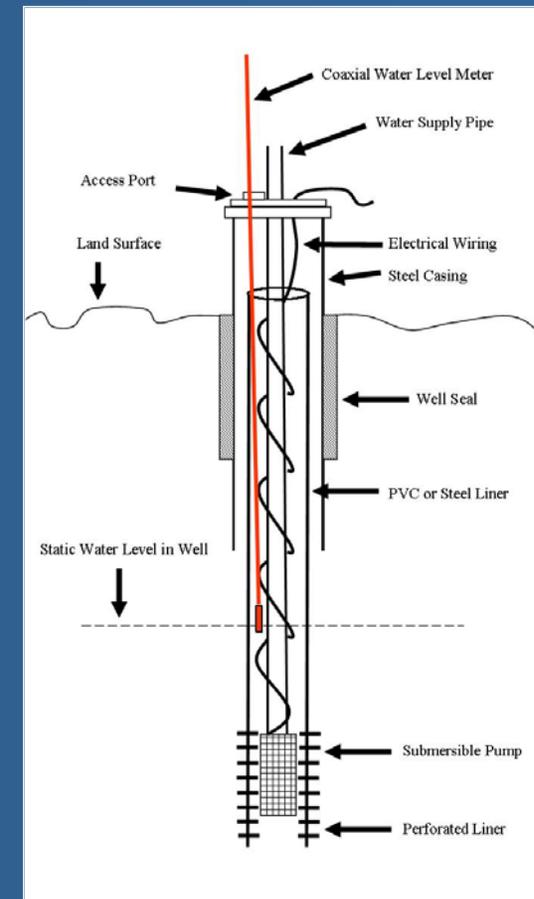
# Citizen Groundwater Level Monitoring

## Water Level Measurement Challenges

### ■ Groundwater 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



# Citizen Groundwater Level Monitoring

## Water Level Measurement Challenges

- Groundwater 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



# Citizen Groundwater Level Monitoring

## Water Level Measurement Challenges

- Groundwater 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
    - c. 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



# Citizen Groundwater Level Monitoring

## Water Level Measurement Challenges

### ■ Groundwater 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



# Citizen Groundwater Level Monitoring

## Water Level Measurement Challenges

### ■ Groundwater Level Measurement Challenges:

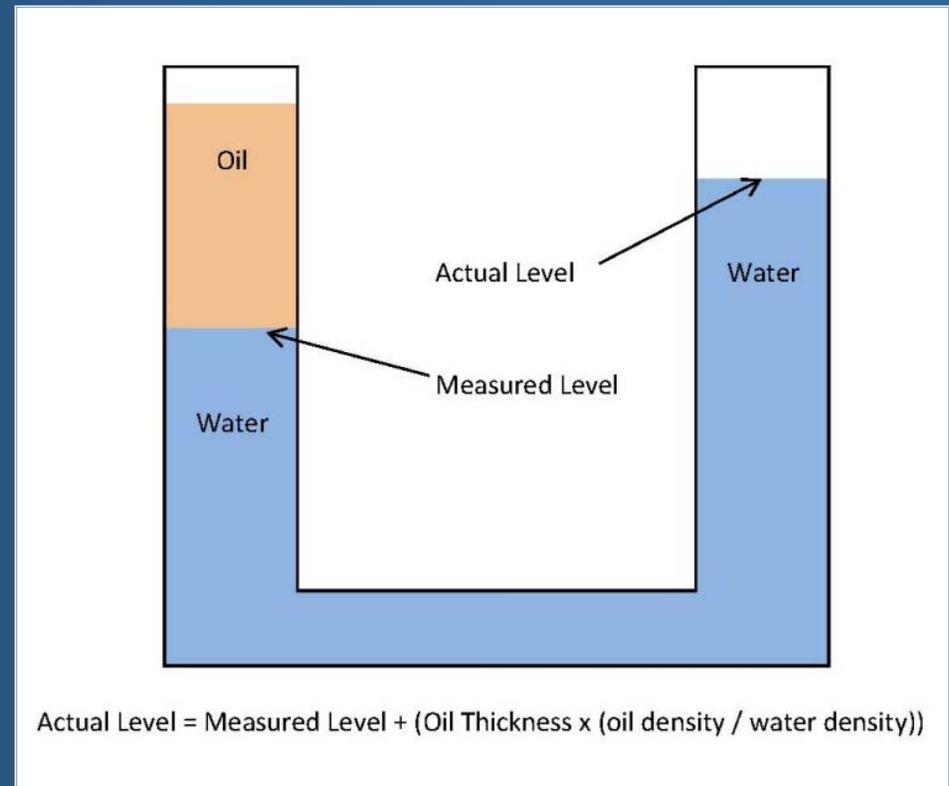
#### 4. Oil Floating on Water in Well

##### 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



# Citizen Groundwater Level Monitoring

Questions & Thank You



Photo by Chad Sobotka