

# Measuring Water Levels in Clayey Created Wetland Soils

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# Today's Topics

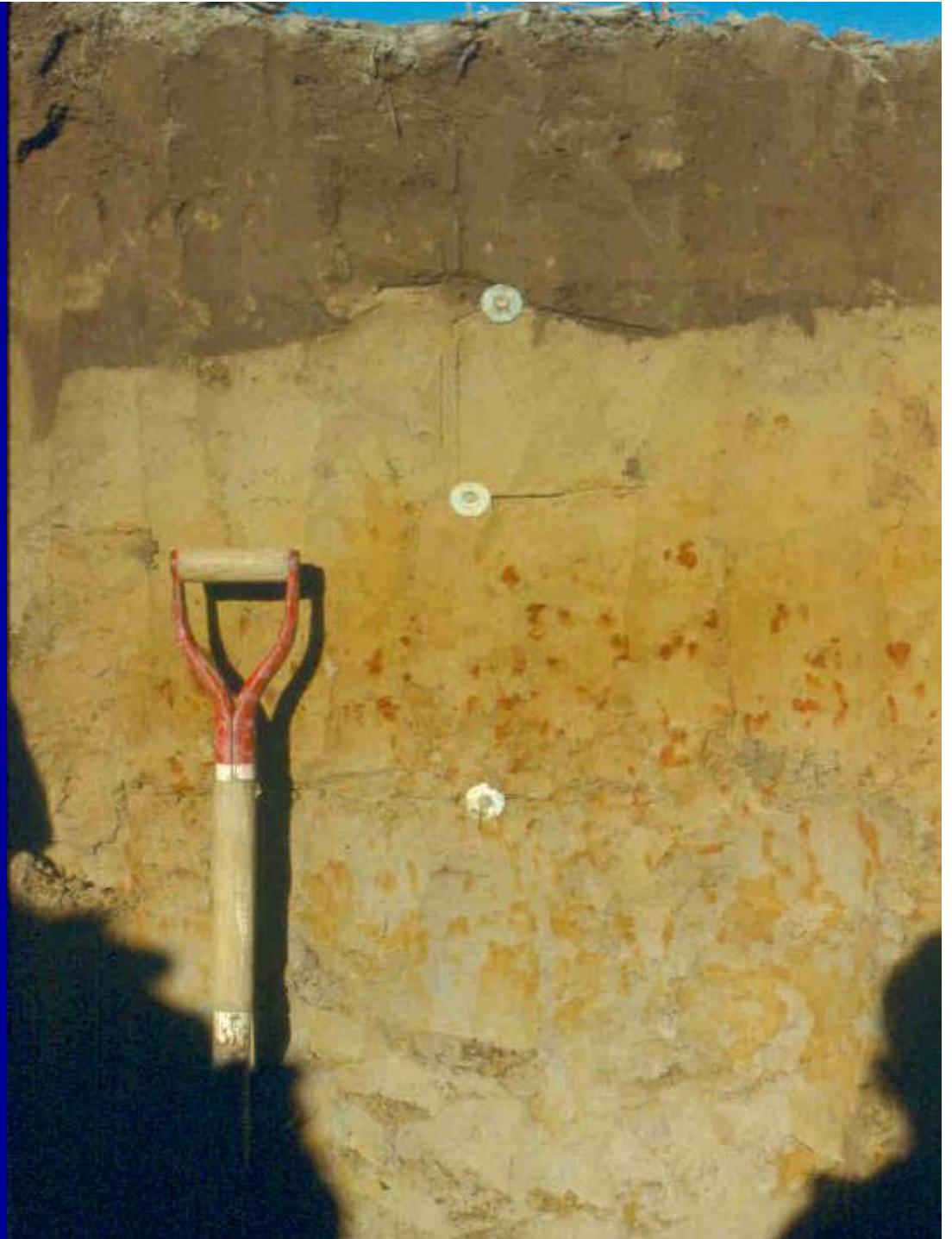
- **Quick review of issues and concerns regarding accurate monitoring of water level/saturation in clayey soils.**
- **Summary of greenhouse/mesocosm study on well and sensor response in a manufactured soil.**
- **Detailed review of field study data comparing multiple well/piezometer designs for > 36 months.**
- **Current “seat of the pants” recommendations.**

**Measuring depth to saturated zones in clayey soils is complicated by:**

- 1. Capillary fringe could be > 20 cm thick.**
- 2. Perching or epiaquic behavior.**
- 3. Soil structure macro- pores intersecting well bores adding/draining water.**
- 4. Presumed slow well response time; > 1 day if  $K_{\text{sat}}$  is  $10^{-5}$  cm/sec.**



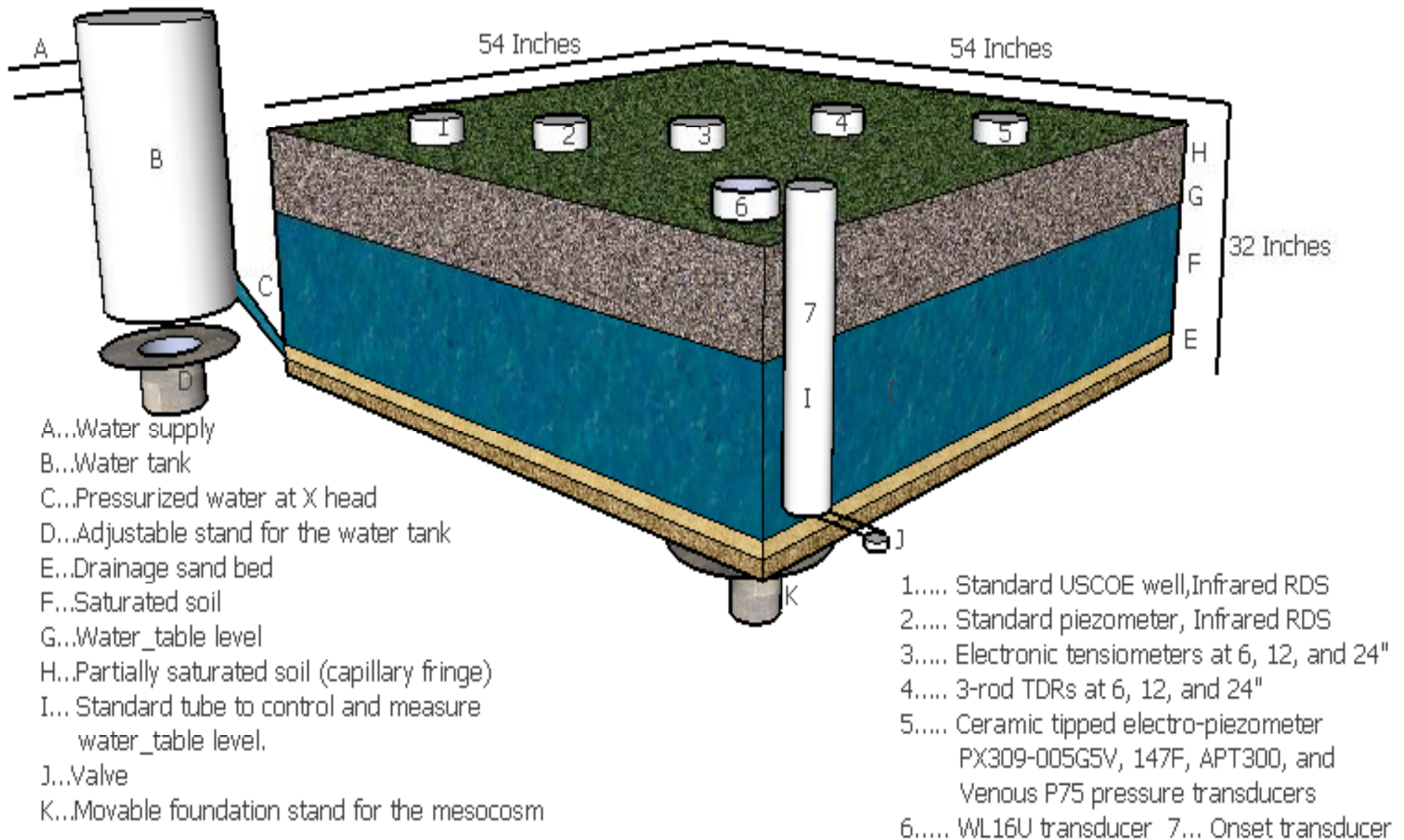
**On the other hand, water levels in sandy endoaquic soils like this one are presumably much easier to measure with conventional wells.**



# Mesocosm Study

- **Designed to evaluate response time and accuracy of conventional wells, piezometers, TDR, and tensiometers.**
- **Conducted in mesocosm tanks with uniform soil manufactured from sand + 30% kaolin clay (sandy clay loam) with  $K_{\text{sat}}$  of  $10^{-4.5}$  cm/sec.**
- **Water levels manipulated up/down in time steps with external & internal monitoring**

# Mesocosm







**Entire array installed with external “step tank” shown. We used pH 8.0 water with 0.02 M  $\text{CaCl}_2$  to keep the system flocculated. No clays/fines were seen in the wells.**



# Mesocosm Results

- All wells & piezometers were installed similar to USCOE 2005 standard but with varying level sensors. TDR and tensiometers also employed.
- Response time of all sensors and well/piezometers was remarkably fast; usually minutes after surrounding soil levels saturated. We saw no significant “lag time” between actual water level in the surrounding soil and the level in the wells.
- Water levels in wells and piezometers were identical and closely corresponded with “tensiometer flips” as the water levels passed through 6”, 12”, etc.

# Cedar Run 3 Wetland Bank

Completed in October 2001  
by WSSI.





0 337.5 675 1,350 2,025 2,700 Feet

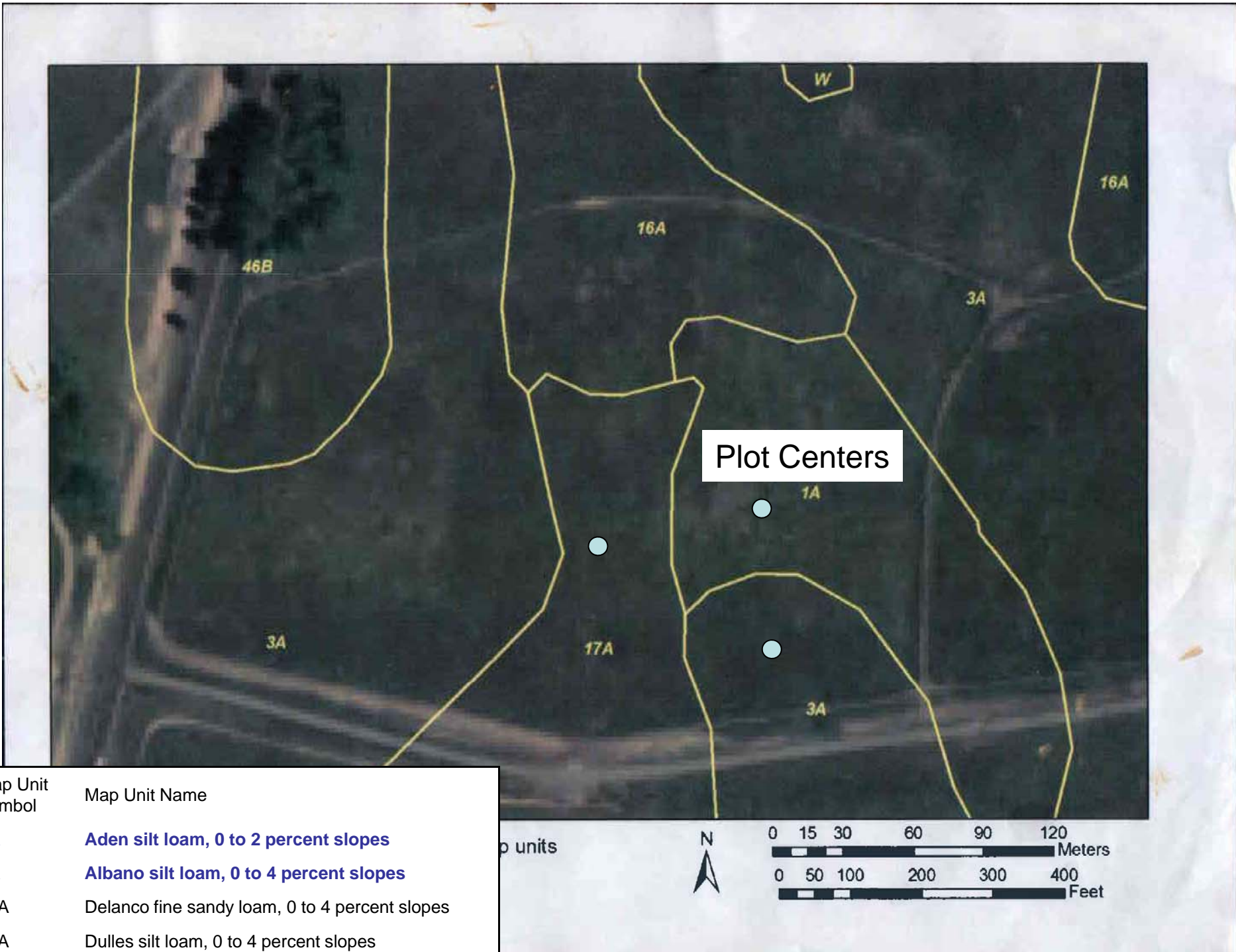


0 295 590 1,180 1,770 2,360 Feet

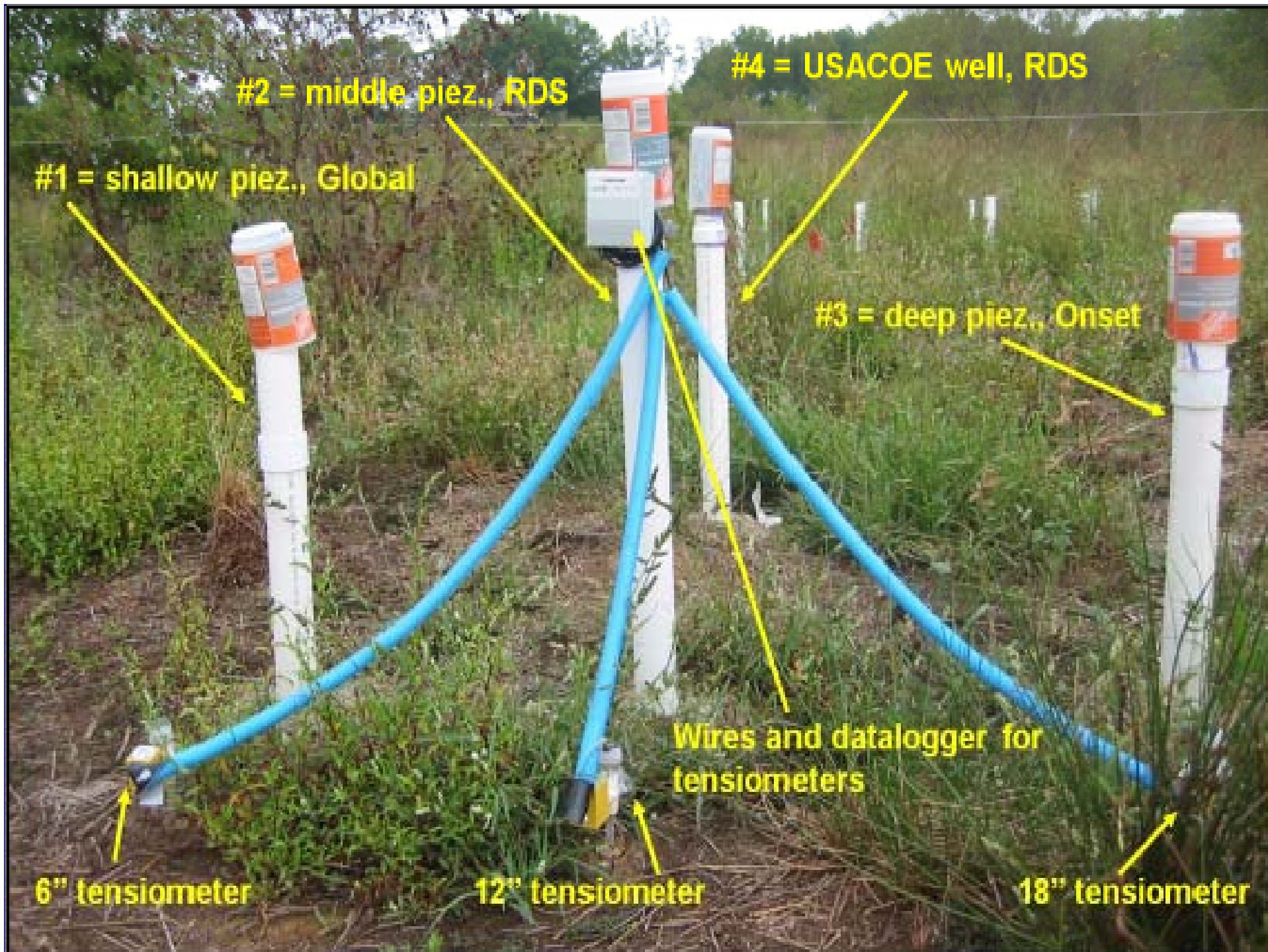


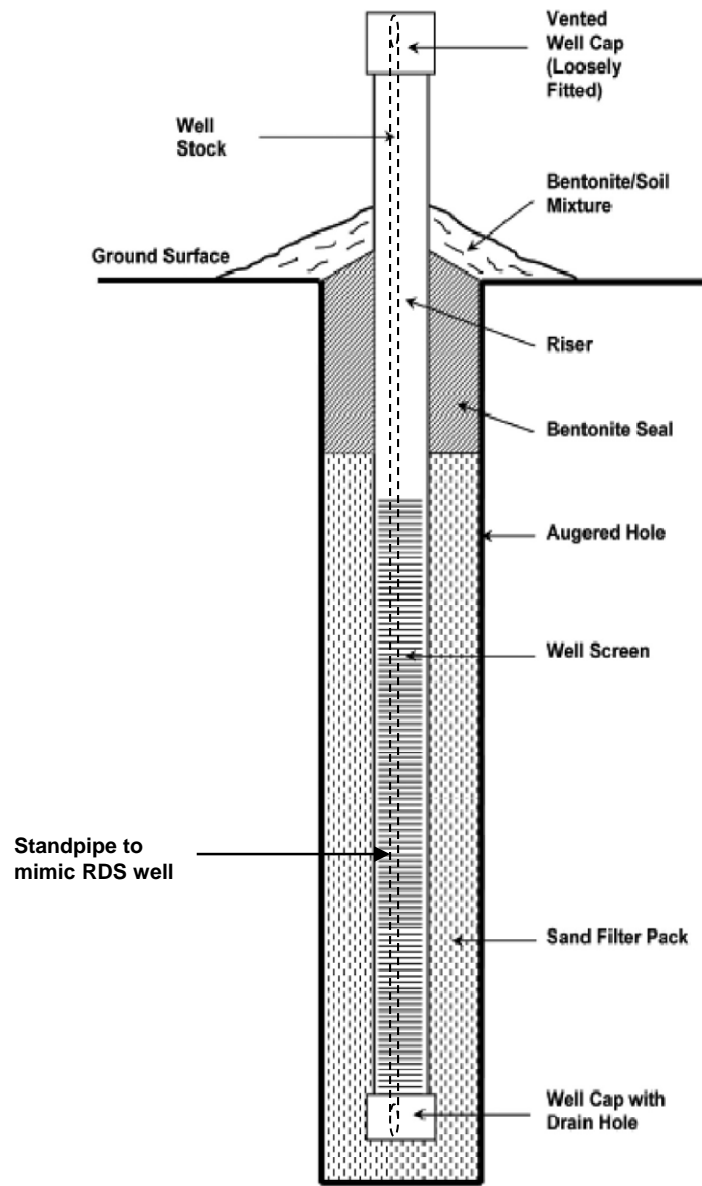
# **Field Study at Cedar Run 3**

- **Installed in August of 2009 at WSSI Cedar Run 3 Wetland Bank in Prince William County.**
- **Site was cut into underlying Triassic origin silty clay subsoil (Bt or Btg) materials and then approximately 30 to 40 cm of Sil to SiCl “topsoil” returned over the cut and “semi-smearred” surface, forming a very distinct textural and density discontinuity.**

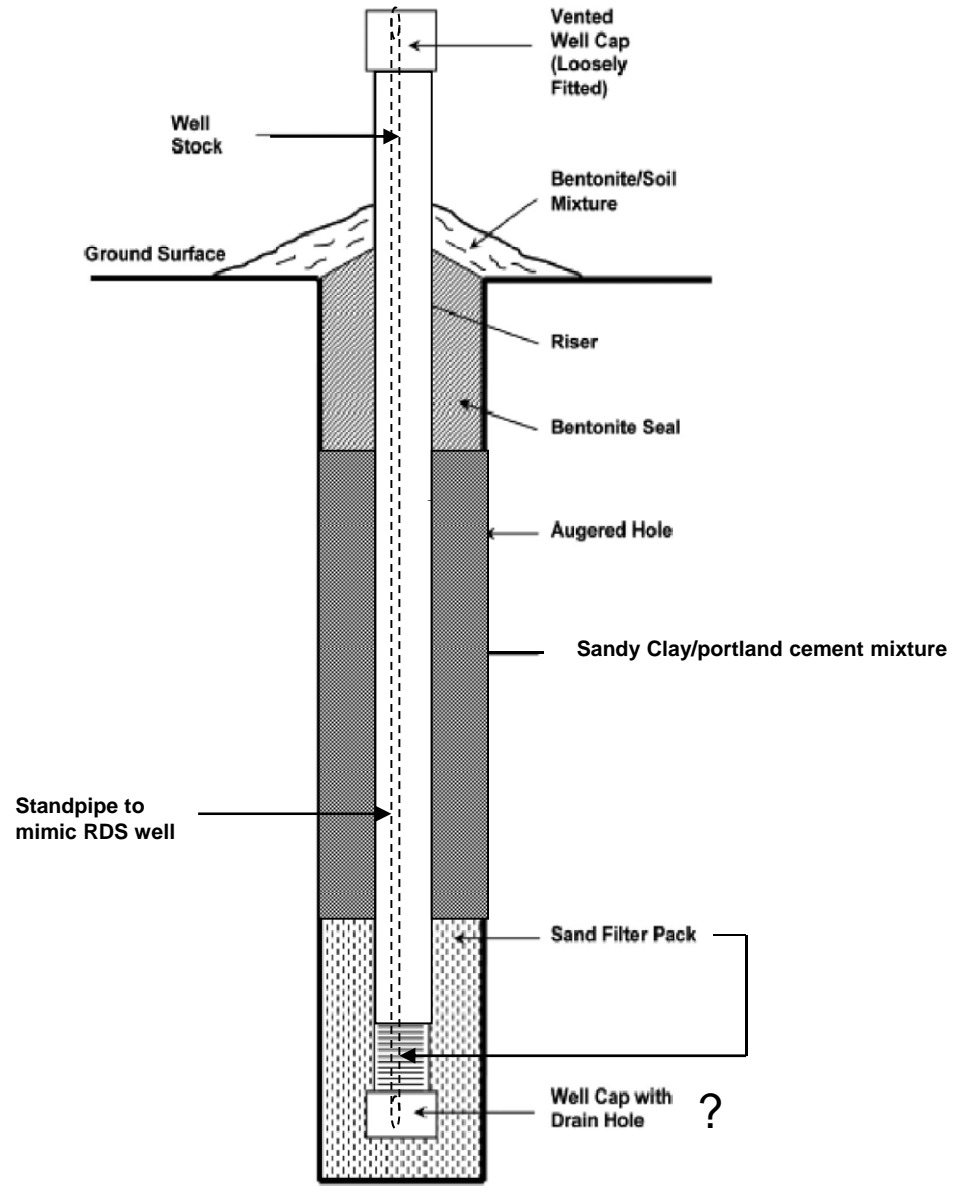






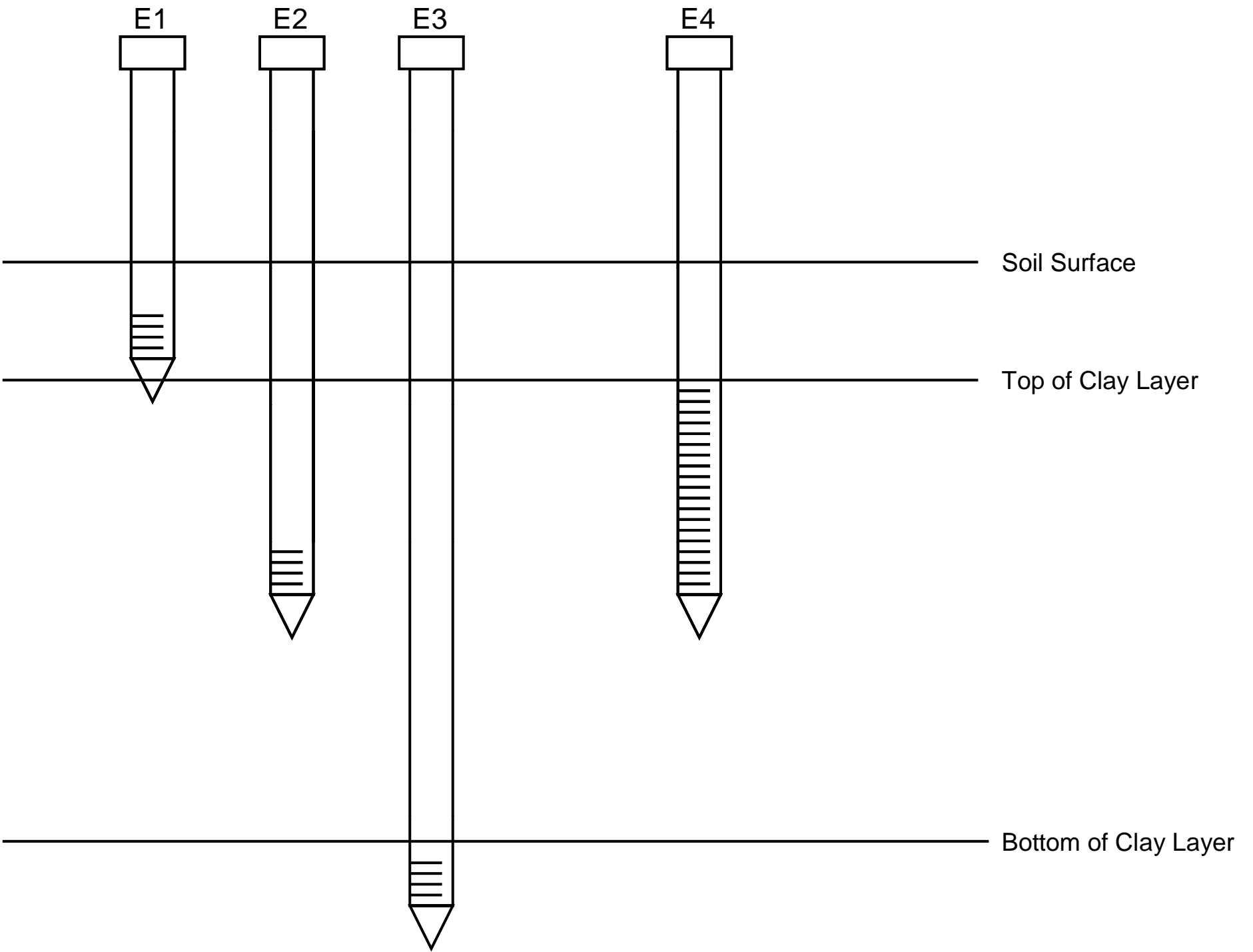


Well



Piezometer





**John  
Galbraith  
and Mike  
Nester  
installing  
well array  
at Cedar  
Run 3.**



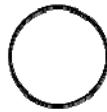
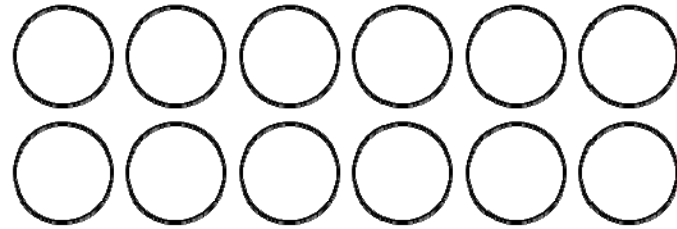
<b>Site</b>	<b>Type</b>	<b>Plot</b>	<b>Rep</b>	<b>Pipe #</b>	<b>Description</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>1</b>	<b>0.75" open hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>2</b>	<b>1.5" open hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>3</b>	<b>0.75" well, sand, 2.75" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>4</b>	<b>1.5" well, SCL, 3.5" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>5</b>	<b>0.75" piezometer, sand, 2.75" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>6</b>	<b>1.5" piezometer, sand, 3.5" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>7</b>	<b>0.75" well, SCL, 2.75" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>8</b>	<b>1.5" well, sand, 3.5" hole</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>9</b>	<b>0.75" well, no pack, tight fit</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>10</b>	<b>1.5" well, no pack, tight fit</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>11</b>	<b>0.5" ceramic piezometer, no pack, tight fit (Note: tight fits had filter fabric wrap)</b>
<b>CR</b>	<b>M</b>	<b>P1</b>	<b>A</b>	<b>12</b>	<b>0.5" hand-cut piez., no pack, tight fit</b>



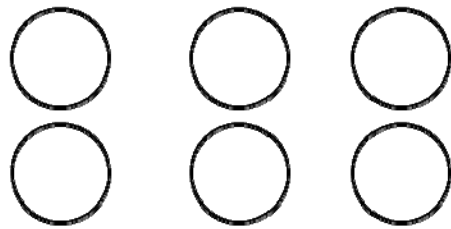
- 1.3 cm (0.5 in) hand-cut piezometer
- 1.3 cm (0.5 in) ceramic cup piezometer
- 1.9 cm (0.75 in) well
- 1.9 cm (0.75 in) piezometer



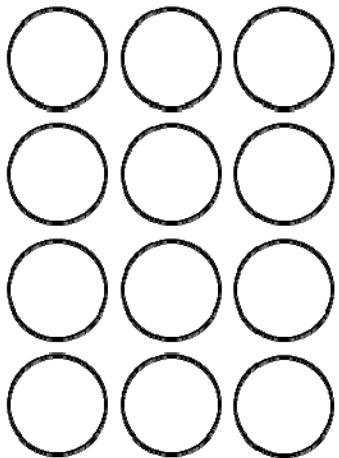
**Manual Rep A**



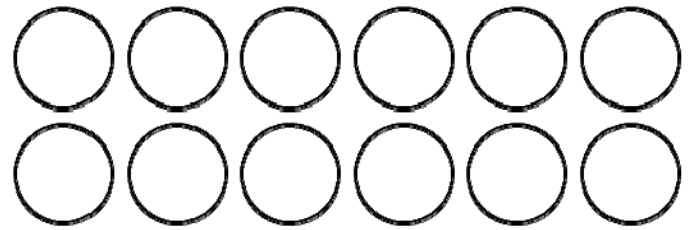
**Electronic Sensor Array**



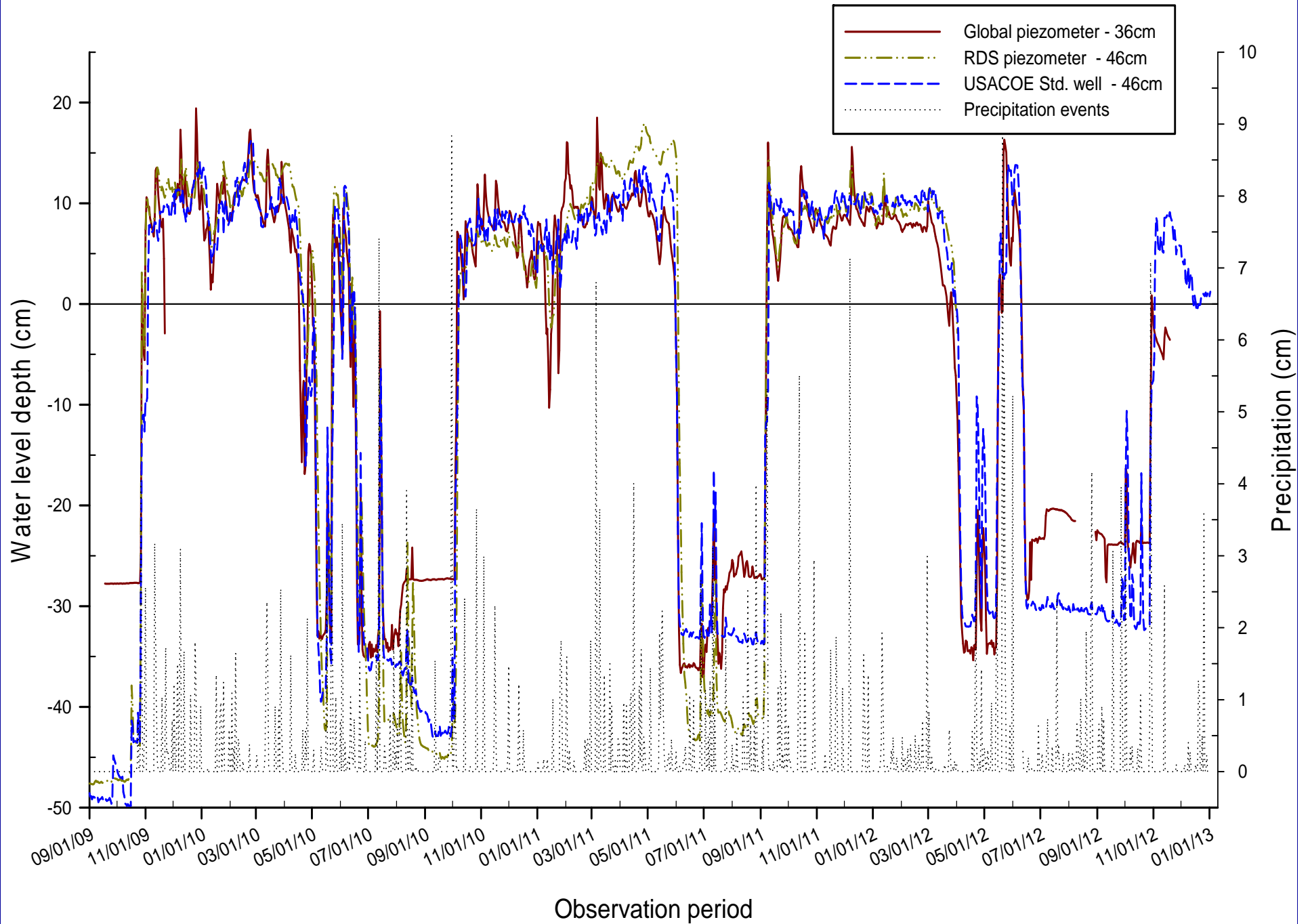
**Manual Rep B**



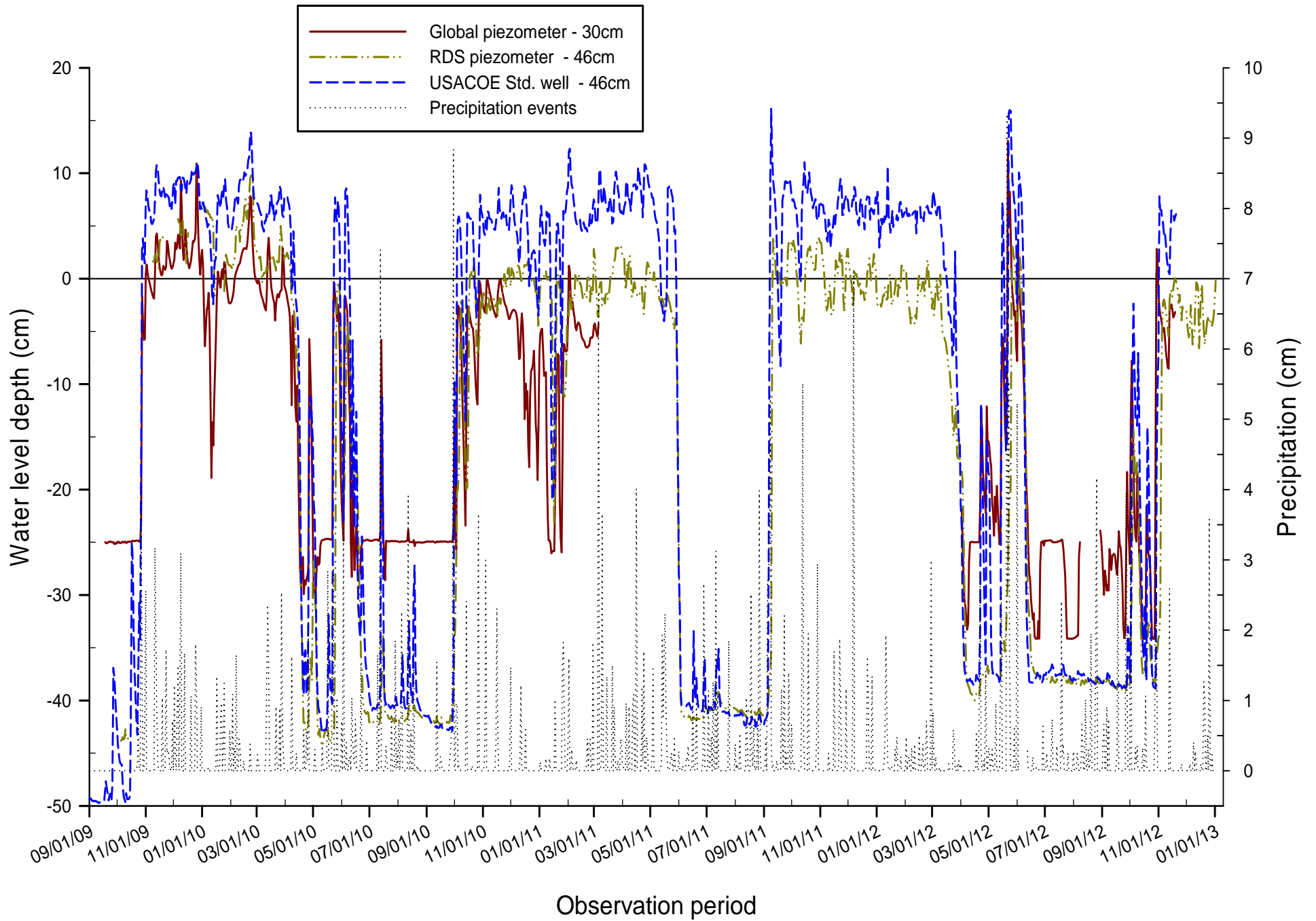
**Manual Rep C**



PLOT #1: Piezometer readings for 3 wells with corresponding precipitation events

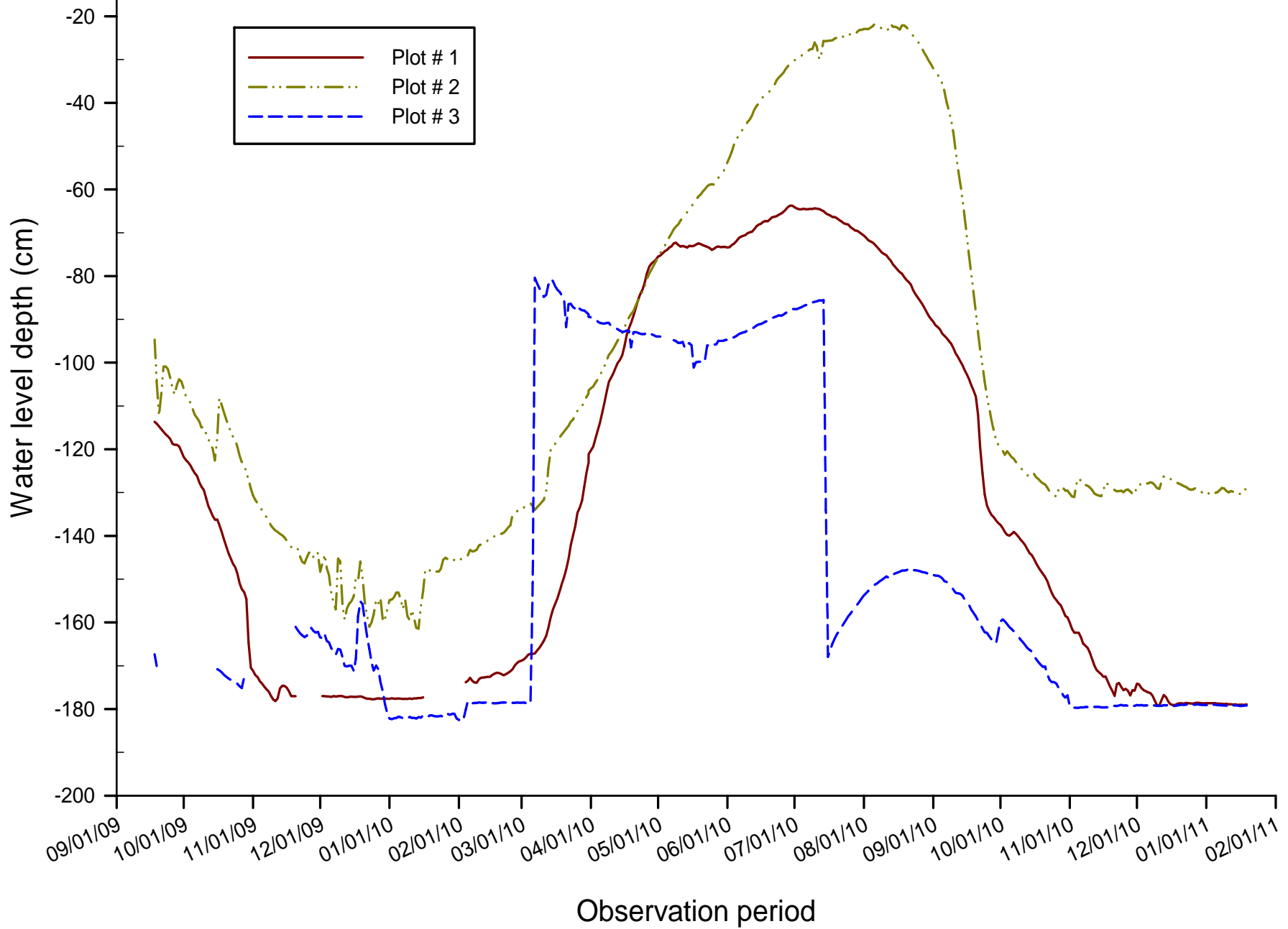


PLOT #3: Piezometer readings for 3 wells with corresponding precipitation events

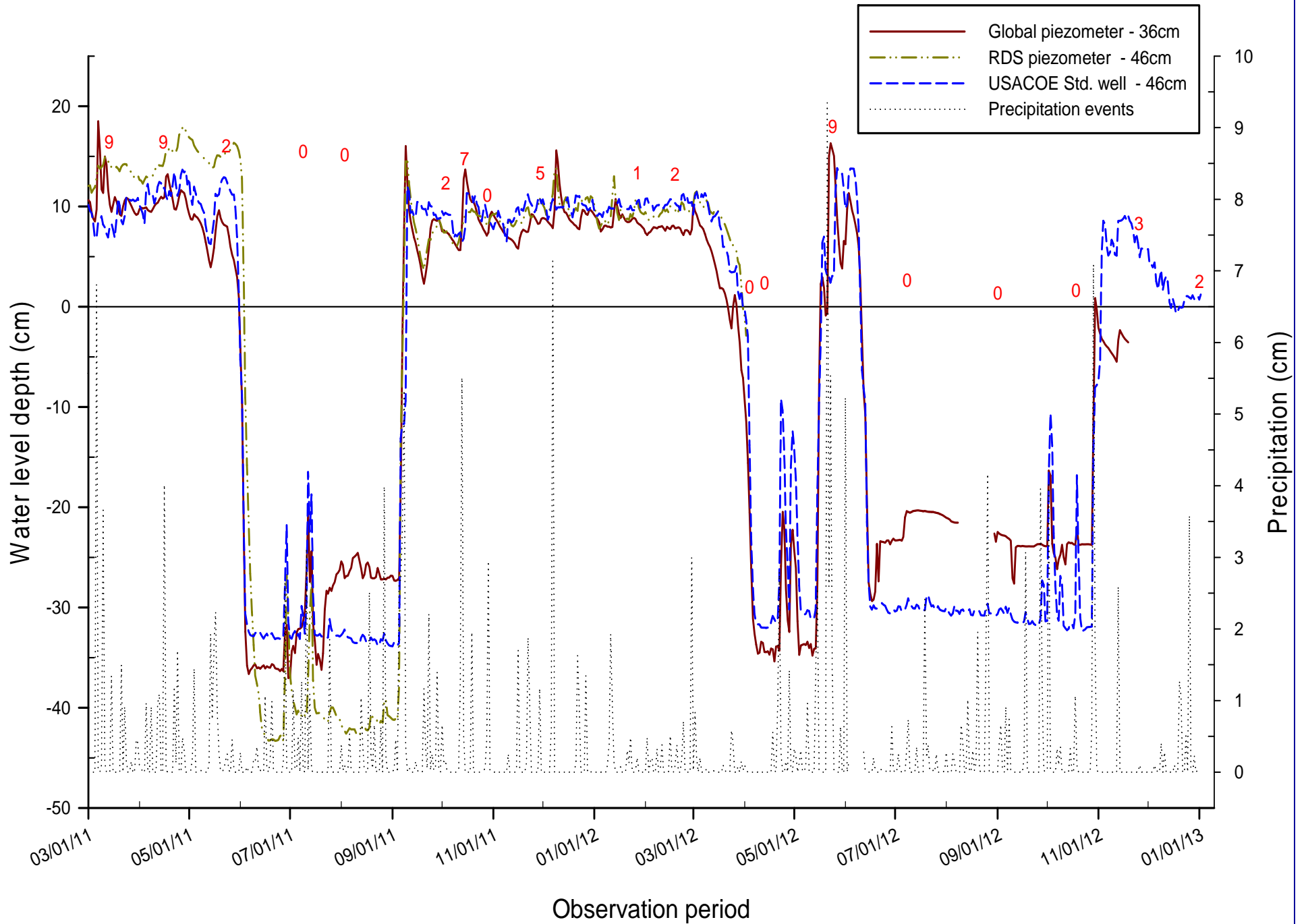




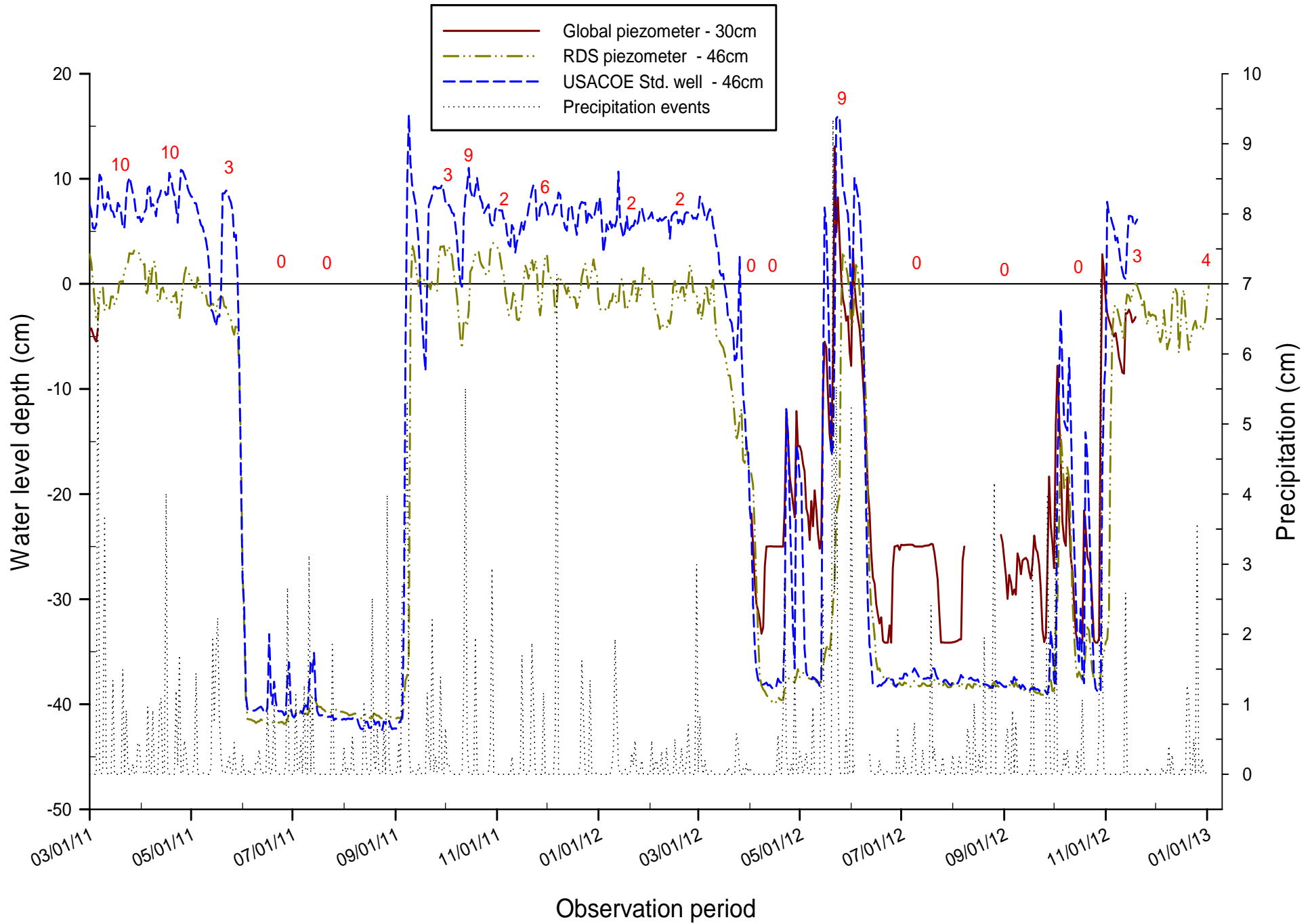
# Deep piezometers (> 150 cm)



PLOT #1: Piezometer readings for 3 wells with corresponding precipitation events

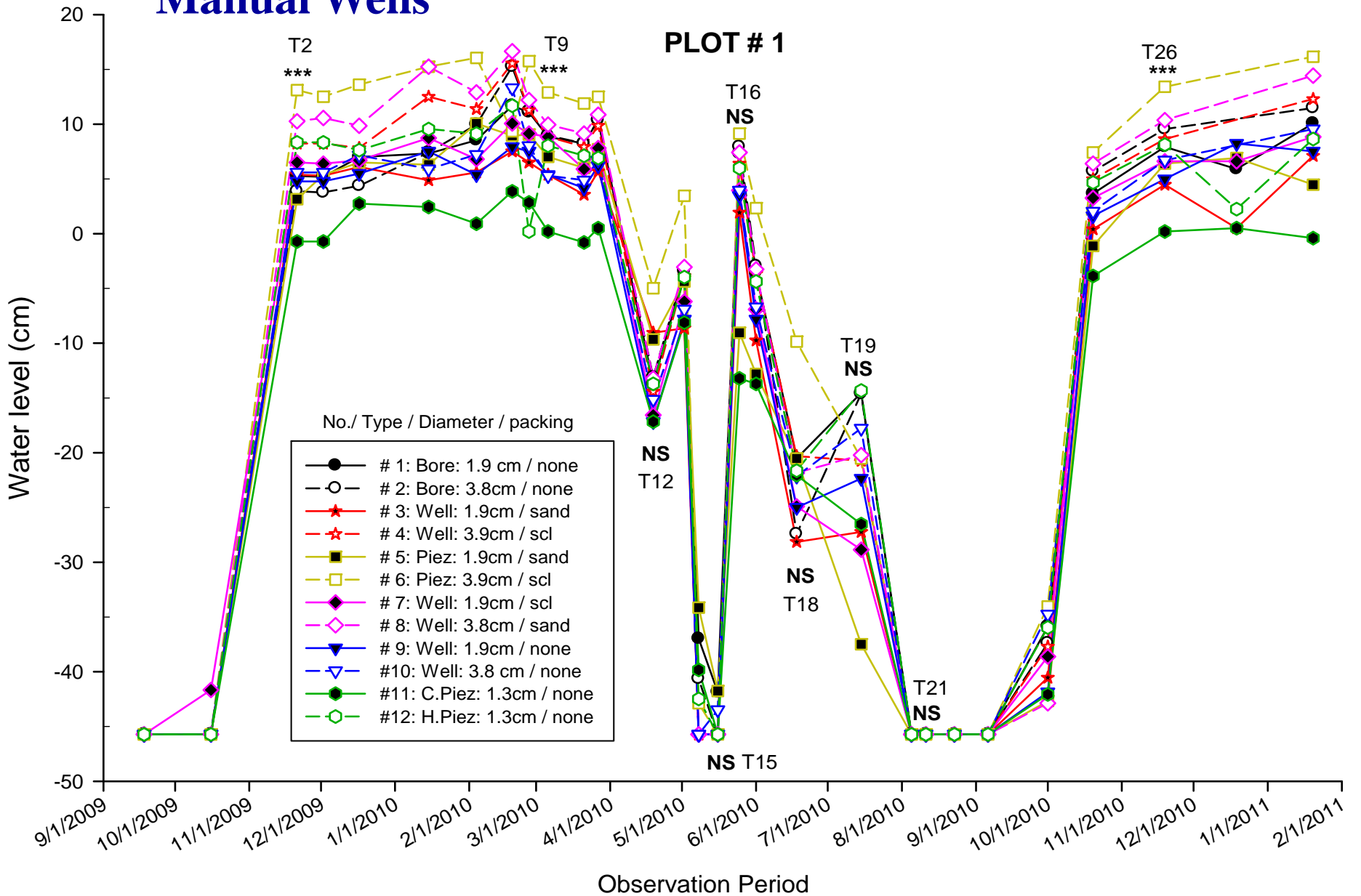


PLOT #3: RDS piezometer and RDS standard well (USACOE) and manual reading of ponded water (cm)

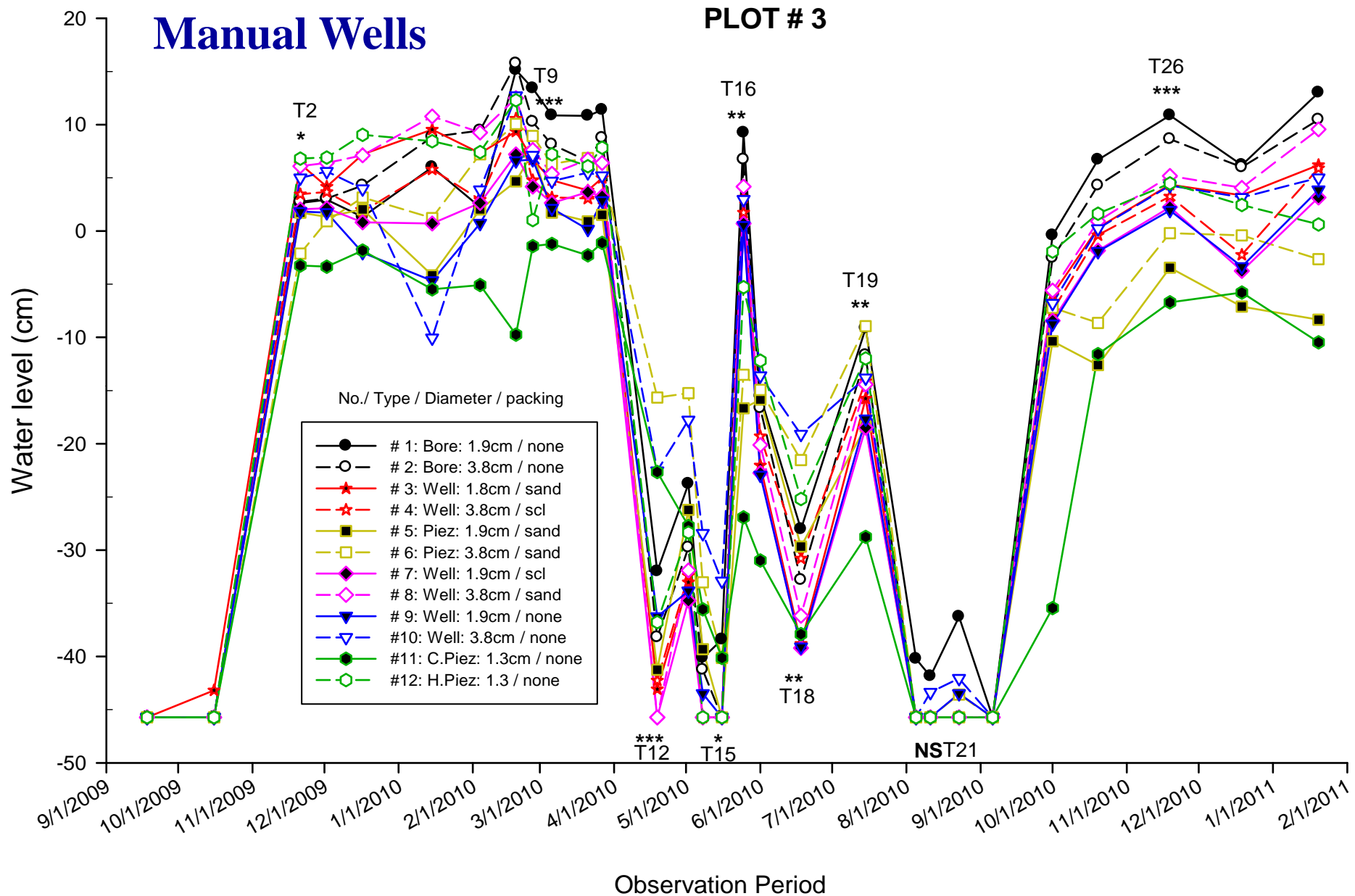


# Manual Wells

## PLOT # 1



\*\*\* Indicates significant (at  $p < 0.001$ ) difference between well types  
 NS indicates not statistically significant difference between well types



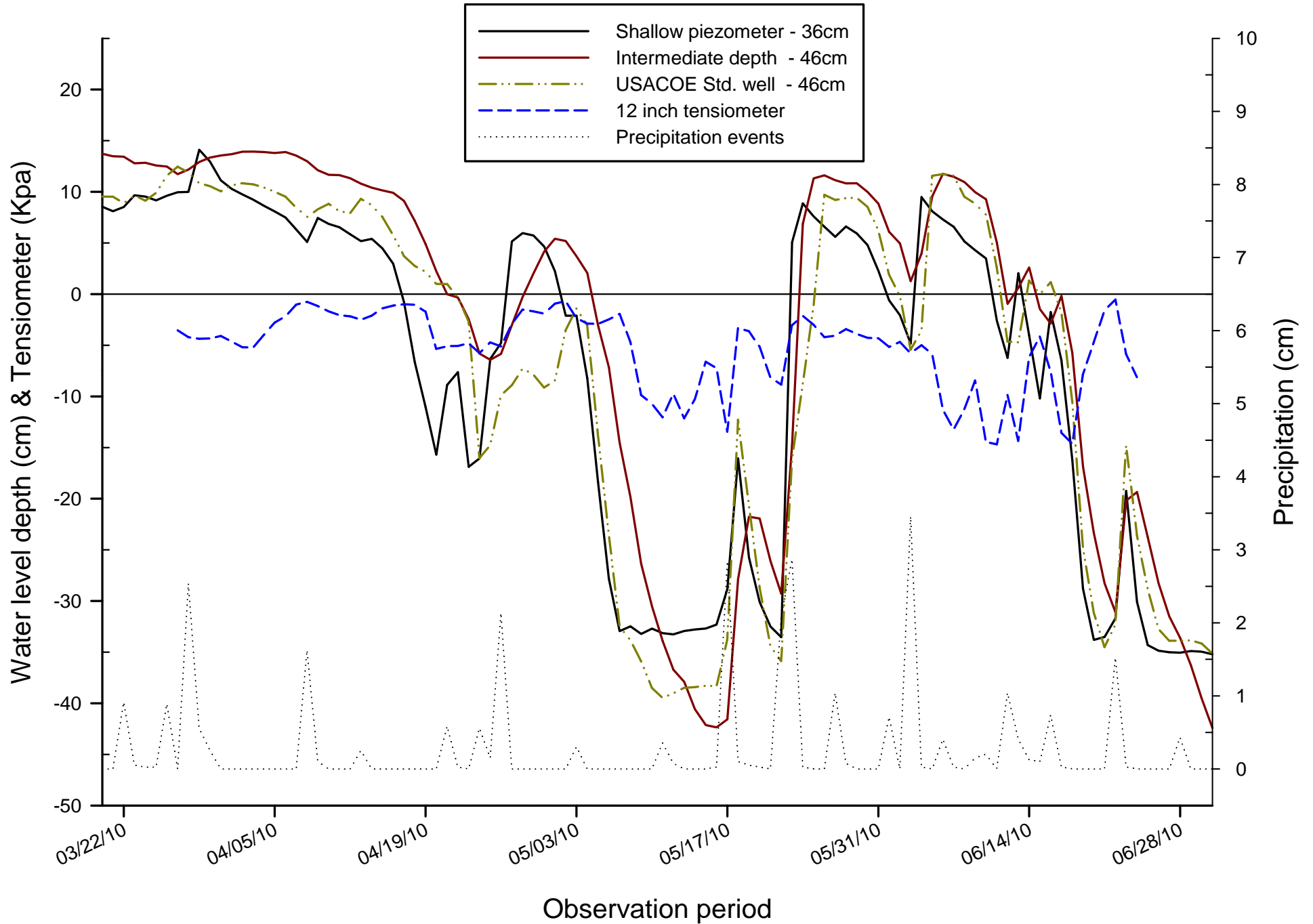
\*\*\*, \*\*, \* Indicates significant (at  $p < 0.001$ ,  $p < 0.01$ ,  $p < 0.05$ , resp.) difference between well types  
 NS indicates not statistically significant difference between well types



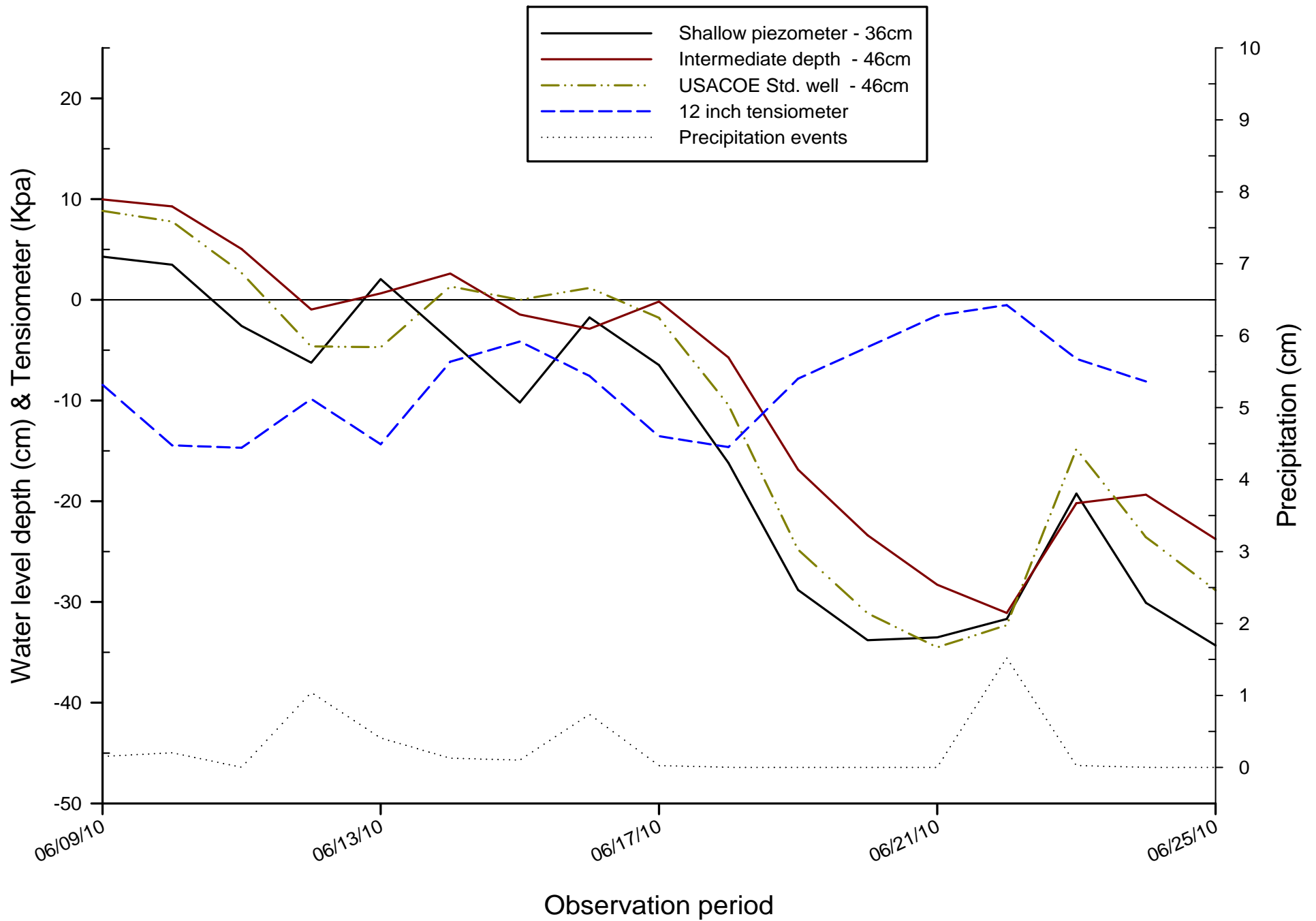
**Spectrum tensiometers used for mesocosm and field plots. Accurate from 0.0 to -0.80 bars (80 centibars). As the soil wets to saturation measured tension goes to 0. As the soil dries down, readings approach 50 to centibars and then “snap” to 0 as water film connectivity is lost. So, as the soil transitions from saturated/unsaturated, the tensiometer “flips” from readings of 0 to net tension and vice-versa. *Maintaining these SOB’s in a field setting is a major pain!***



PLOT #1: Piezometer vs 12" Tensiometer readings for 3 wells with corresponding precipitation events



PLOT #1: Piezometer vs 12" Tensiometer readings for 3 wells with corresponding precipitation events





# Conclusions

**Our mesocosm results may indicate that concerns over “lag time” of well or piezometer response may not be warranted.**

**In a simple, homogeneous and unconfined system, wells, piezometers and tensiometers all accurately indicate the top of the saturated zone (zero potential surface).**

# Conclusions

**The standard USCOE well and the similarly constructed nested piezometers “tracked well” for overall growing season determinations, particularly when ponded.**

**The piezometer nest (~ 30 and 46 cm) allowed a more detailed interpretation of seasonality of flux. The shallow piezometer gave a much more accurate reading of the dynamics of the surface ponded/saturated zone during the wetter periods of the year.**

# Conclusions

**Differences in well/piezometer diameter, design, and packing texture/fit produced surprisingly different “apparent water level” readings that varied as much as 15 to 30 cm during both the winter ponded periods and summer subsoil water table flux periods.**

**However, all the well/piezometer designs tested produced a similar overall temporal response (with different absolute levels).**

# What would I use today?

**If I knew that I had a relatively uniform soil (e.g. no textural discontinuities), I would be comfortable using the current USCOE standard well, regardless of soil texture.**

**However, if a significant discontinuity exists, I would use a simple piezometer nest such as employed here and use both data sets to interpret hydroperiod.**

# What would I use today?

On the other hand, if all “really wanted to know” was whether or not the soil was saturated at a given depth for a significant period of time, I would use a robust tensiometer set at that depth with a data logger. However, this will not generate a “hydroperiod” curve for you nor will it tell you whether or not the zone you are sensing is “perched/epiaquic” or not.



**Commercial Irrrometer™ type tensiometers being prepared and as installed. These are robust and accurate, but must be modified for data recorders etc.**

# Acknowledgements

We want to thank James Burton and Mike Nester for their help in the field. WSSI assisted us with the manual well readings and provided weather data. Mike Beck conducted the statistical analyses and provided the graphics.

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Peterson Family Foundation

