Effects of well design and sensor type on the measured hydroperiod of a high clay created wetland soil in Virginia, USA.

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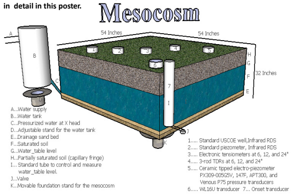
VirginiaTech **Crop & Soil Environmental Sciences**

Photo 1: Overall mesocosm design used to test all sensors; results not described in detail in this poster.

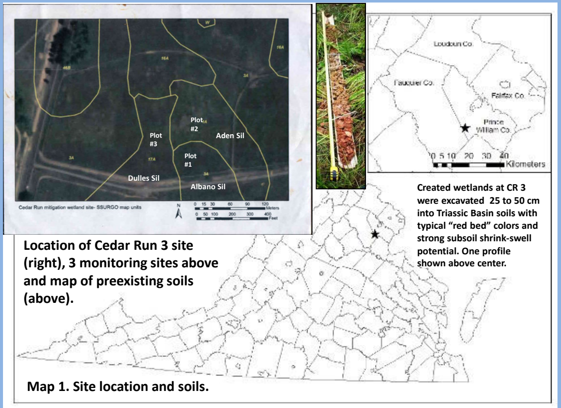


Introduction and Methods:

Accurately monitoring depth to saturation in clayey compacted soils within created wetlands is complicated by a number of factors including the capillary fringe, soil structure effects, and presumably, slow water level response time in wells and piezometers. Furthermore, current created wetland designs in the eastern USA frequently rely on a heavily compacted subsoil layer to limit groundwater seepage losses which frequently creates epiaquic conditions where the surface saturated zone is intermittently "perched" above deeper unsaturated zones. Standard monitoring wells are often open-screened from –15 to –45 cm and that open screened increment may include both unsaturated and saturated zones, potentially resulting in erroneous estimations of the actual depth to saturation (zero potential surface).

The overall objective of this research program is to determine the most accurate combination of well design and sensor technology for monitoring the actual height/depth of saturation in high clay soils in created wetlands.

First, we investigated the accuracy and response time of standard USCOE wells, nested piezometers, tensiometers and TDR probes in greenhouse mesocosms filled with a uniformly compacted and structureless sandy clay loam soil as we precisely varied depth to saturation (Photo 1). All designs/devices tested were relatively accurate at predicting depth to saturation and their response time was surprisingly rapid. In a follow-up study at a 7 year-old created wetland with a compacted high clay subsoil in Prince William Co., VA (Map 1, below), we monitored over 140 wells, piezometers and tensiometers of varying design. At each of three replicate locations (Map 1), we monitored standard USCOE wells, piezometer nests, tensiometer nests and 12 different well/piezometer designs (3 reps each at 3 location) where we varied soil boring and well diameter, installation depths, screen and filter pack specifications, and other parameters (see Fig. 1, Table 1 and Photos 2 and 3). All wells and sensors were monitored for 15 months and the central array of automated wells was monitored for 36 months.



Location of Cedar Run 3 site (right), 3 monitoring sites above and map of preexisting soils (above).

Created wetlands at CR 3 were excavated 25 to 50 cm into Triassic Basin soils with typical "red bed" colors and strong subsoil shrink-swell potential. One profile shown above center.

Map 1. Site location and soils.

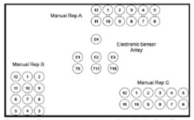


Figure 1. Layout of monitoring wells at Cedar Run Plot 1.

Table 1. Description of manually monitored wells/piezometers at each replicate.

Site	Type	Plot	Rep	Trt. code	Description
CR	E	P1	-	E1	Shallow piezometer, 1" above Btg, Global
CR	E	P1	-	E2	Middle piezometer, 18" below surface, RDS
CR	E	P1	-	E3	Deep piezometer, 1" below Btg, Onset
CR	E	P1	-	E4	USACOE Standard Well, 18" below surface, RDS
CR	E	P1	T6"	T6	Tensiometer @ 6"; silica flour pack
CR	E	P1	T12"	T12	Tensiometer @ 12"; silica flour pack
CR	E	P1	T18"	T18	Tensiometer @ 18"; silica flour pack
CR	M	P1	A	M1	0.75" open boring
CR	M	P1	A	M2	1.5" open boring
CR	M	P1	A	M3	0.75" well, sand pack, 2.75" boring
CR	M	P1	A	M4	1.5" well, SCL pack, 3.5" boring
CR	M	P1	A	M5	0.75" piezometer, sand pack, 2.75" boring
CR	M	P1	A	M6	1.5" piezometer, sand pack, 3.5" boring
CR	M	P1	A	M7	0.75" well, SCL pack, 2.75" boring
CR	M	P1	A	M8	1.5" well, sand pack, 3.5" boring
CR	M	P1	A	M9	0.75" well, no pack, tight fit
CR	M	P1	A	M10	1.5" well, no pack, tight fit
CR	M	P1	A	M11	0.5" ceramic piezometer, no pack, tight fit
CR	M	P1	A	M12	0.5" hand-cut piezometer, no pack, tight fit

Type: E = Electronic wells; M = Manual wells.

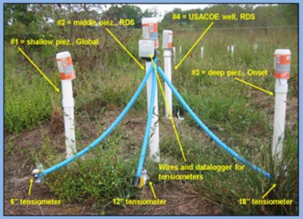


Photo 2: Continuous water level monitoring array at center of each of three sites. Different sensors (RDS, Global^{tm} and Onset^{tm}) were employed along with tensiometers at varying depths.

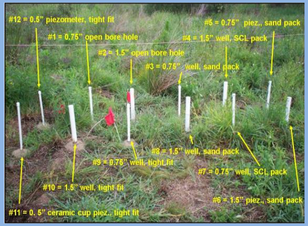


Photo 3: 12 well designs were evaluated in 3 replications at each location (9 total reps). See Figure 1 above for overall monitoring array layout.

Figure 2: Plot 1 water levels via continuous recording wells.

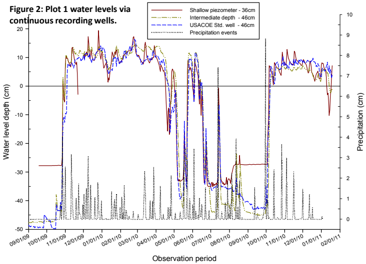


Figure 3: Plot 3 water levels via continuous recording wells.

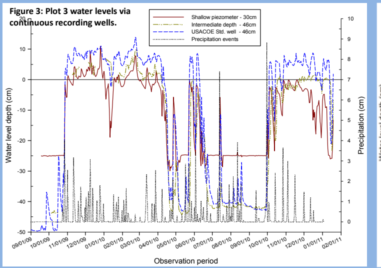
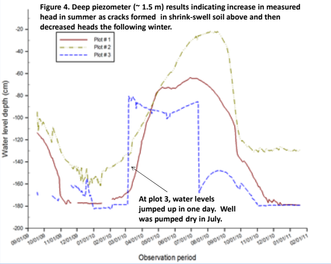
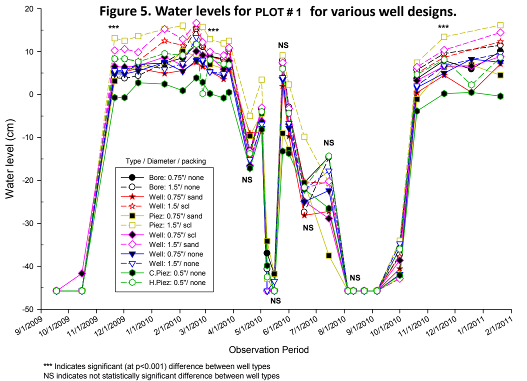


Figure 4. Deep piezometer (~ 1.5 m) results indicating increase in measured head in summer as cracks formed in shrink-swell soil above and then decreased heads the following winter.



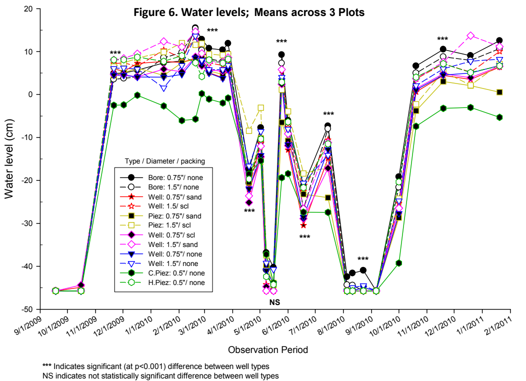
At plot 3, water levels jumped up in one day. Well was pumped dry in July.

Figure 5. Water levels for PLOT # 1 for various well designs.



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

Figure 6. Water levels; Means across 3 Plots



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

Results & Conclusions:

Overall, this site exhibited a very complex seasonal hydroperiod (Figs. 2 and 3) where during the winter months it remained ponded and fully saturated to – 0.5 m, but was unsaturated at ≥ 1m in the soil/saprolite interface region (Fig. 4). During the spring and early summer, the site dried from the surface and water levels dropped regularly. However, summer and fall storms generated frequent perching events where as much as 20 cm of ponded/saturated soil was maintained for extended periods above an unsaturated subsoil until deep cracking appeared to allow deep water percolation (Fig. 4) to > 1 m. In the fall, the site was typified by a perched (epiaquic) system until sufficient slow percolation plus local groundwater inputs saturated the subsoil and led to a fully "reconnected" saturated zone to 50+ cm. Standard USCOE monitoring wells generated a similar seasonal response to both shallow (15 cm) and moderate depth (45 cm) piezometers, but as expected, projected an integrated water/head level between the two piezometers during the drier summer period. Both the standard USCOE wells and the shallow piezometers occasionally projected ponded levels in the winter when on-site measures indicated no ponding occurred, however, and their short-term response to rainfall events varied widely from site-to-site and over time. While all of the 12 different well/piezometer designs evaluated here generated a similar overall seasonal response, they varied as much as 20 cm in measured water levels during the wet ponded winter period and even more strongly during summer wet/dry cycles (Fig. 5). The relative response of certain designs (e.g. open auger hole vs. ceramic cap piezometers) varied strongly among the three replicate sites. Across all sites (Fig. 6), the highest relative levels were projected by open bore holes and 1.5' sand packed wells + piezometers while the lowest levels were seen the ceramic cap piezometers. Further analyses are ongoing to compare subsurface water level projections against our tensiometer data sets to determine the absolute accuracy of the various designs when the saturated zone is below the surface. Overall, well design variations strongly affected apparent water levels during both winter ponded and summer unsaturated periods, but differences did not appear to be strong enough to affect jurisdictional determinations.

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