Advanced Tensiometers

The objective of this subtask was to obtain soil water potential data for calibration of numerical models and for estimating unsaturated hydraulic properties.

Materials and Methods

Advanced Tensiometers (AT) were installed through a hollow stem auger to selected depths at the Sisson and Lu Site. The depths chosen were selected on the basis water content data obtained during the original Sisson and Lu experiments. Sisson and Lu (1980) reported that injected water spread rapidly over layers with initially high water contents that indicated finer textured soils with lower hydraulic conductivities. Table 1 presents a list of borehole locations and depths to which AT's were installed.

Table 1. Borehole locations and depths (ft) of AT's.

H2	H4	H6
16.2	16.4	18.6
20.8	19.4	23
30.5	30.8	29
36.8	35.9	30.9
39.3	39.5	35.9

In addition to the AT's installed through the hollow stem auger 4 AT's were installed as drive cone tensiometers. The drive cone tensiometers were manufactured from porous stainless steel and were pushed to depth. Table 2 presents the locations and depths of the drive cone tensiometers.

Table 2. Locations and depths(ft) of drive cone tensiometers.

A3	F2	H6
17.5	16	17.1
24.5		

Following installation of the porous cup portions of the AT's, pressure sensors equipped with rubber stoppers were inserted in the porous cups and wired to a data logger at land surface (See Sisson and Hubbell, 1998 and Hubbell and Sisson, 1998).

Results

Soil water potentials obtained for leaks 3, 4 and 5 are shown on figures 1 though 3. The figures show that the tensiometers were not fully operative until day 161 (June 8, 2000), although once operational the tensiometers performed reliably. The early response seen in the water potentials obtained at 36.8 ft in borehole H2 is typical for tensiometers installed in large diameter boreholes. The backfill material placed around the AT was in a liquid state and the water drains for sometime before reaching the water potential in the surrounding soils. At some sites as long as 6 weeks have been required to allow the equilibrium state to be reached.

Figure 4 shows soil water retention curves obtained by combining soil water potentials with water contents obtained using neutron probes. The retention curves are essential inputs to the numerical models being used to predict flow and transport at the Hanford Site. It should be noted here that the water contents and water potentials were measured at different spatial points and were separated by distances of 1 to several feet (See plan view of the site).

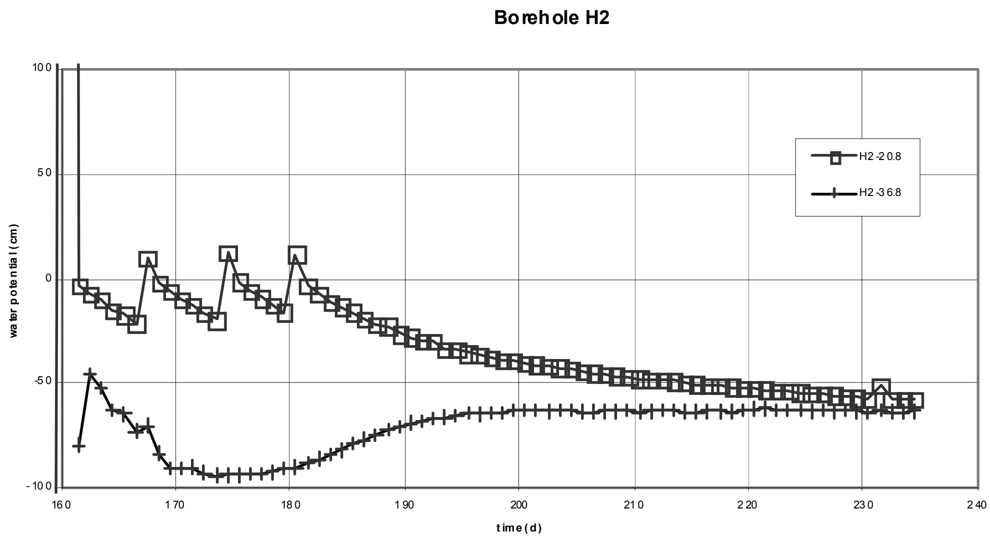

Figure 1. Soil water potentials for borehole H2. See Plan view of site for location.

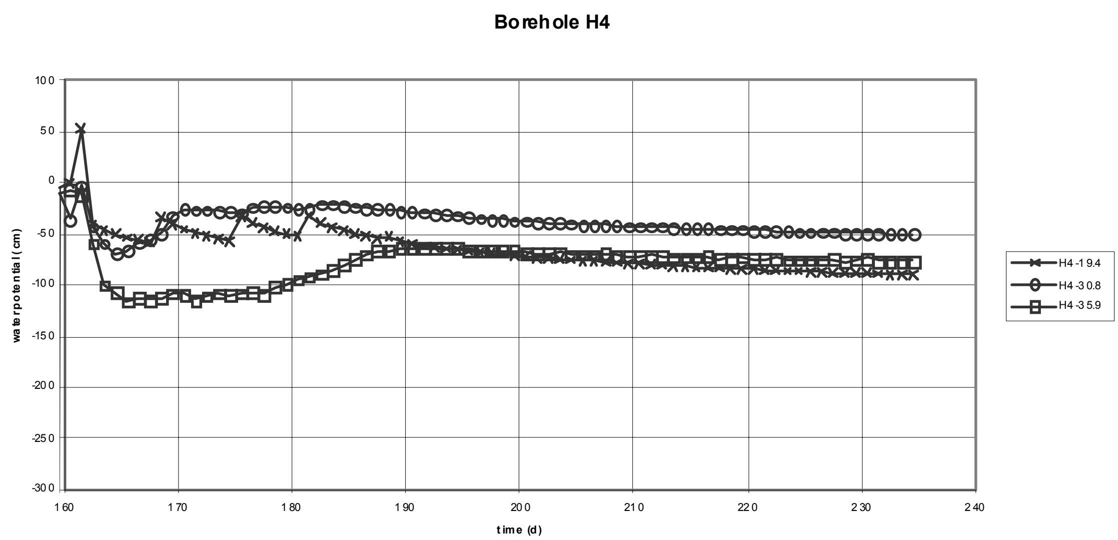

Figure 2. Soil water potentials for borehole H4. See plan view for location.

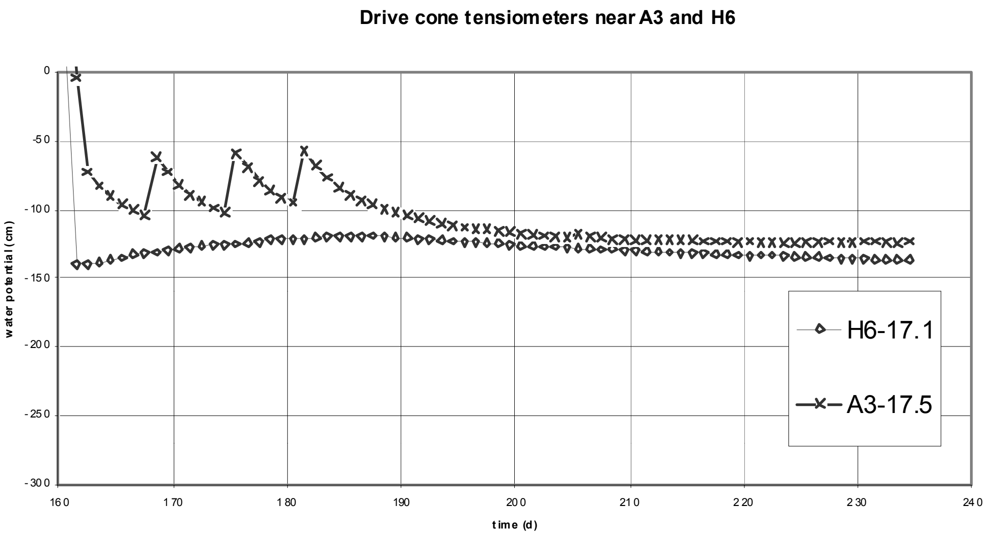

Figure 3. Drive cone tensiometers near A3 and H6. See plan view for location on site.

Discussion

Initial problems resulted from the deployment of a new style pressure sensor that did not seal reliably resulting in air leaking into the tensiometers. The failure of the seals appeared to have allowed some of the pressure sensors to move past the end of the porous ceramic cup, causing the cup to fail. Setting these problems aside we were able to obtain portions of the needed retention curves *in situ* at significant depths. Prior to this experiment the only retention curves obtained *in situ* have been near land surface or using tensiometers inserted through caisson walls (See figure 4).

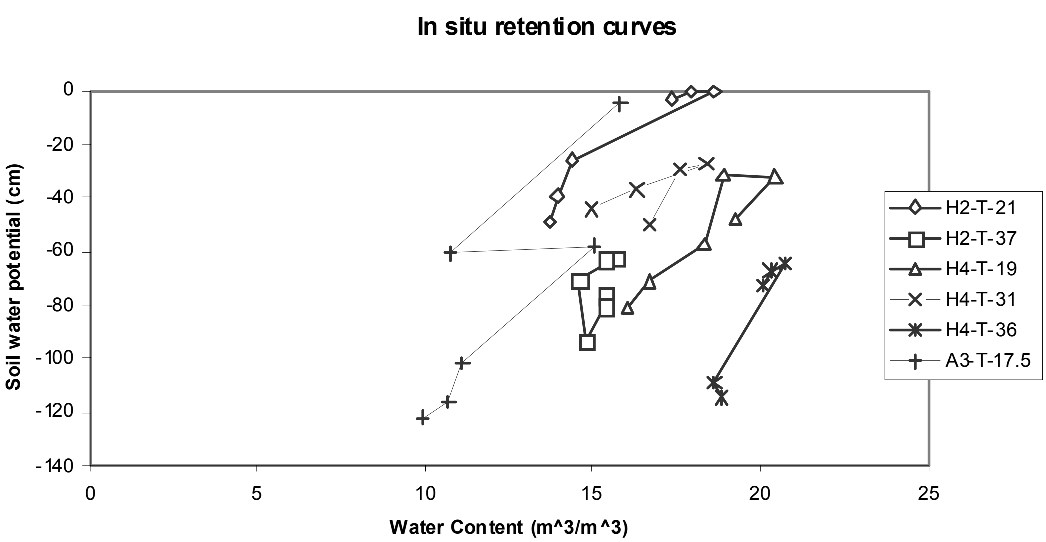

Figure 4. In situ retention curves obtained at the Sisson and Lu Site.

The data presented on figure 4 is dissimilar to laboratory obtained retention curves in that the saturated values of water content (i.e. water content at 0 water potential) are typically less the 0.25 m^3/m^3 where as laboratory results indicate saturated water contents above 0.30 m^3/m^3. These differences could be the result of the field results being from soil under significant overburden pressure, differences between disturbed samples and undisturbed soil, or differences resulting from dynamic field conditions and static laboratory conditions. The dynamic versus static conditions explanation can probably be discarded on the basis of literature results showing higher water contents under dynamic then under static conditions (Wildenschild and Hopmans, 2000; Plagge and Haupl, 2000). The marked discontinuity demonstrated in the retention curve for borehole A3 at 17.5 ft depth could result from the rather large spatial distance between the drive cone tensiometer and the point where water contents were obtained (See plan view). Thus, the data were obtained under different soil moisture regimes.

Recommendations for further experiments

Since the retention curves are important to the modeling effort an additional experiment needs to be conducted to better define the curves near saturation. The experiment could consist of simply injecting a pulse while taking closely spaced in time water contents. The data acquisition rate for water potentials should be increased to 4 or 6 per hour to obtain data during the wetting phase. Also the tensiometers with broken ceramic cups need to be repaired to better fill in the data sets through the soil volume encompassed by the experiment.

References

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