

Site Characterization in the Kansas River Alluvium

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Site Characterization in the Kansas River Alluvium

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The Kansas Geological Survey (KGS) has initiated an intensive field study of the hydrogeology of the Kansas River alluvium near Lawrence, Ks. The major emphasis is on the evaluation of the threat that waste-disposal facilities in the alluvium may pose to groundwater resources. The initial focus of the project is on the testing and refinement of methodology for characterization of the flow and transport properties of the subsurface alluvium. An experimental field area has been established for this purpose. In order to define the subsurface geology, eighteen wells were drilled at the field site in 1988 with a hollow-stem auger. Cores were taken using an inexpensive saturated-sand sampler manufactured at the KGS after the design of Zapico et al. (1987). Several modifications were made to the sampler in an attempt to decrease the need for the addition of drilling fluids. The cores are being analyzed using a constant-head permeameter to assess the nature of small-scale variations in the vertical component of permeability. The analyses are being carried out using the original 4-5 foot long cores recovered during drilling. Pressure transducers are implanted along the vertical axis of a core. A program of hydraulic testing has been initiated at the site using both slug and pumping tests. The slug tests employ inflatable straddle packers to isolate discrete zones in the alluvium. A series of pumping tests were carried out at the site in 1988 allowing the large-scale flow behavior of the alluvium to be investigated. The collection of data detailing permeability variations at the core through pumping-test scale should allow some insight to be obtained concerning the scale dependence of permeability at this site and its relationship to the geology of the alluvium. Ideally, a suite of appropriate techniques for characterizing permeability in alluvial aquifer systems will evolve from this work.

Site Characterization in the Kansas River Alluvium

Slide 1 - This afternoon I would like to briefly discuss a few aspects of some field work that we have been pursuing in the Ks. River alluvium near Lawrence, Ks. The major focus of our work to date has been on the detailed characterization of a particular site in the Ks. River alluvium. The motivation for this work arises out of the fact that groundwater makes up approximately 85% of all water used in Kansas. A relatively large portion of that 85% comes from alluvial aquifer systems. Since a large number of waste-disposal sites are located on floodplains in Ks., there is a real need to evaluate the potential threat that such sites pose to the water resources of the alluvium. The primary goal of our work is to identify appropriate field techniques for use in the hydrogeologic environment presented by alluvial sequences. In order to evaluate the appropriateness of various field methods, it is necessary that we characterize a particular field site in considerable detail. Such a site can then present a somewhat controlled environment for methodology assessment. Today, I will be discussing work related to this initial characterization effort.

Slide 2 - This presentation will be organized in the following manner. I will begin by providing a brief introduction of conditions at the specific site of our characterization efforts. Then I will focus on two aspects of the

characterization work: first, the approach used for obtaining relatively undisturbed cores in saturated sands and gravels, and second, the laboratory arrangement for measuring the hydraulic conductivity of the obtained cores.

Slide 3 - Let me begin by describing the site at which we currently are focussing our efforts.

Slide 4 - The research area is in the northern portions of Douglas County about 3 miles northeast of the city of Lawrence on land owned by the University of Kansas. The specific tract of land on which the field site is located is a portion of the Kansas Ecological Reserves administered by the Experimental and Applied Ecology Program of the University of Ks. The work I am discussing today is concentrated in the area marked B on this map,

Slide 5 - A blowup of that area is shown here. The work to date has taken place in the cleared region in the southeast corner of the area and has been centered on a pre-existing high-capacity pumping well. In the 1988 field season, we began out work in this area by drilling the three nests of 2 in. piezometers shown here. I should note that all the 2 in. piezometers were drilled using hollow-stem auger methods.

Slide 6 - Here is a picture of the site showing the high-capacity pumping well on the left and the northernmost nest of piezometers on the right.

Note that one well of a larger diameter is set off from the others in the nest- that is a well that was drilled into the bedrock underlying the alluvium using mud-rotary methods. This well was set off from the others in order to minimize the impact of drilling fluids on the piezometer nest.

Slide 7 - A cross-sectional view of that northernmost nest illustrates the major units in the subsurface at the site. Although this slide is a convenient representation of subsurface geology, I should point out that there is considerably variability within each of the units. One of the primary purposes of the nesting arrangement was to assess how this intra-unit variability is reflected by flow behavior under unstressed and stressed conditions.

Water-level monitoring over the last six months has shown that the primary direction of flow in a vertical section is downward from the clays and silts and upward from the sandstone into the sand and gravel unit. Preliminary analysis of data from a series of pumping tests at the site indicates that the transmissivity of the sand and gravel unit is approximately $1200 \text{ m}^2/\text{d}$ (roughly 100,000 gpd/ft).

The first goal in our characterization effort was, during the development drilling at the site, to obtain a series of relatively intact cores from

each of these major units in order to begin to understand the nature of intra-unit and inter-unit variability at the site.

Slide 8 - I would now like to describe several aspects of our efforts to obtain cores that have been disturbed to a minimum extent. Traditionally, obtaining cores in saturated sands and gravels has been a rather difficult task - as most of the material falls out of the core barrel before reaching the surface, resulting in a very low percentage of recovery.

Recently, work done at the Univ. of Waterloo has shown that recovery percentages in saturated sands and gravels can be significantly increased by a piston arrangement in which a piston, set in a plastic or aluminum liner in a core barrel, is placed at the bottom of the hole and the core barrel advanced past the piston setting up a suction that can hold the sample in the liner as the core barrel is retrieved.

Slide 9 - At the Kansas Geological Survey, we built a sampler, based on this principle, which is shown here. This slide depicts the core barrel with the plastic liner, the cutting shoe, and the piston with O rings to maintain the suction. In our sampling, we attempt to drive or push our coring device a distance of five feet in advance of the auger flights.

When drilling muds were used during augering, we were able to obtain percentages of core recovery in excess of 90%. The loss that was

occurring was primarily reflected in the accumulation of water at the top of the sample and was attributed to a combination of compaction, side-wall friction with the liner, and the sucking action of the piston.

Now, we were interested in using a technology that did not require the introduction of drilling fluids, since such fluids undoubtedly influence the measurement of the physical and chemical properties of material both in core and downhole. When we attempted to use this piston sampler without drilling fluids, we found that we were losing a considerable amount of material out the bottom of the sampler. The % loss ranged from 30%-40% on the low side, to virtually 100%. We tried to use a catcher basket, shown here in yellow, but found it did not improve recovery significantly while it did disturb the sample quite a bit. The fingers of the catcher apparently were being held apart by grains that were lodged in during the advancing of the core barrel, and thus had difficulty in retaining the sample on retrieval. We therefore decided to modify the original design of the sampler in an attempt to prevent material from falling out the bottom of the core barrel during retrieval. Our modification, based on the design of Carl McElwee, involved this cutting shoe.

Slide 10 - The modified cutting shoe that was constructed is shown here. Note

that this design is based on an external movable sleeve that controls the deployment of retractable steel fingers that can move out of the side of the cutting shoe as the core barrel is retrieved from the hole.

When the core barrel is being advanced, the sleeve is in this position, as the side-wall friction exerted by the sediments through which the sampler is being driven forces the sleeve to the back end of the cutting shoe.

Slide 11 - With the sleeve in this position, a shot down through the cutting shoe shows the steel fingers just peeking out from the sides. Note that, in this shot, the fingers are slightly further out than they would normally be for illustrative purpose.

Slide 12 - At the start of the retrieval process, the upward motion, in conjunction with side-wall friction exerted by the surrounding sediments, forces the sleeve to move from the position shown here,

Slide 13 - to this position. This downward movement of the external sleeve acts to deploy the steel fingers,

Slide 14 - as shown here.

We have had very good success with this device when the fingers deploy with the first upward movement of the core barrel. However, we have found that side-wall friction does not always immediately trigger the movement of the fingers, so we may still lose 30-40% of the sample. Thus, we have been considering a more reliable triggering mechanism, such as one involving

hydraulics. We are also exploring the potential of the downhole freezing of the end of the sample using liquid nitrogen. Although the work reported here is not complete, we think it does indicate that our goal of consistently obtaining 90+% core recovery in saturated sands and gravels, without the addition of drilling fluids, is possible.

Slide 15 - Given that we can obtain relatively intact cores, one of the properties of the cores that we would like to measure is hydraulic conductivity. And we would like to be able to measure the hydraulic conductivity using the cores obtained with our sampler without any repacking. X-ray work done on similarly obtained cores from the USGS Cape Cod project has shown that the assumption of a relatively undisturbed core is quite good. Thus, we feel that the hydraulic conductivity values obtained from the original cores are a reasonable representation of values in situ.

I would now like to spend a bit of time discussing a permeameter that we have set up in the laboratory to perform these hydraulic conductivity measurements.

Slide 16 - Here is a general shot of the permeameter setup that we have constructed. The core is in the central portion of this shot. Our setup has been designed to function either as a constant- or falling-head permeameter, although we have only used it in a constant-head configuration to

date. We have a recirculating system so water flows from an upper reservoir through the sample into a lower reservoir where a sump pump then transport the water back to the upper level. The point we would like to emphasize here is our automation of the measurement task through use of pressure transducers connected to a data logger. This transducer-data logger configuration is quite useful as it allows us to avoid much of the routine monitoring that normally is associated with such experiments.

Slide 17 - Here is a closer view of a core placed in the setup. Note that water actually flow upward though the sample in this configuration before being discharged into the clear plastic outlet tube on the right in which we measure the flow rate using a pressure transducer. You can see that pressure transducers are emplaced along the axis of the core allowing the hydraulic conductivity of small sections of the core to be measured. Also note that, with each transducer, there is a manometer whose level is read on the left. I should point out that this sample is in its original liner and has not been disturbed since it was acquired except during transportation from the field and during the installation of the transducer ports.

Our initial plan was to avoid resaturation of the cores since our sampling approach allows us to obtain saturated samples. We have found, however, that when the samples are stored for several months, extensive evaporation through the walls of the plastic liners will occur. Thus, we have had

to resaturate the cores before analysis. In the future, we will be analyzing the cores shortly after sampling in order to avoid this evaporative loss and, consequently, the need to resaturate the sample.

Slide 18 - Here is a closeup of one of the pressure transducers showing the associated manometer. By frequent cross-checking of the manometer and transducer values and periodic recalibration of the transducers, we are able to obtain quite accurate measurements of the hydraulic conductivity variations along a core. The width of the interval between transducer ports (typically 6 in. to 1 ft. in our experiments) is a function of the accuracy and stability of the employed transducers. Thus, periodic calibration of the transducers is critical.

Slide 19 - The recalibration procedure we use is quite simple and employs the large tube to the left of the permeameter. We place the transducers in the manifold at the bottom of the tube and compare the height of the column of water in the tube to the transducer output. Once again, the transducers are attached to the data logger allowing a record of the calibration to be stored for future reference.

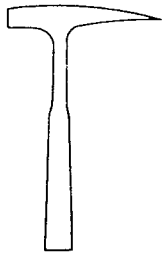
I should point out that the analyses have not gone as smoothly as we had initially anticipated due to problems with bacterial growth in the core and chemical precipitation and dissolution. After considerable experimentation, we

now have set up a procedure whereby we attempt to complete the analysis of each core within 24-48 hours after it is placed in the permeameter. We also employ water from the field site, which has come into equilibrium with the laboratory environment, in our recirculating permeameter. We are hopeful that rapid analysis and the use of the natural waters will allow us to circumvent the problems we have seen.

Although we are still in the early stages of our core analyses, we have found that the automated system described here is extremely useful, as its unattended data collection capabilities allows us to perform core analyses with a minimum amount of labor and a high degree of accuracy.

Slide 20 - In summary, this presentation has been a progress report of a project that just reached the end of its first year. The purpose of this presentation was three-fold: first, to present a general overview of the site; second, to discuss our efforts in the development of a saturated-sand sampler that does not require drilling fluids; and third, to discuss the automation of a constant-head permeameter arrangement. I would like to emphasize that the work reported here is part of a detailed characterization effort at a site that we hope can serve as a relatively controlled environment for the testing and refinement of field techniques appropriate for use in alluvial sequences.

Thank you for your attention.



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May 17, 1989

Kathryn Hess
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Kathy:

Here are the details on the KGS cutting shoe designed by Carl McElwee that I promised you a while back. I have enclosed five color prints of the cutting shoe in various stages of disassembly, a slide of the assembled shoe, and a copy of Carl's latest drawing of the shoe. I have also enclosed a copy of our AGU presentation sans slides. As you can see from the materials, the shoe works in a very simple manner. The external sleeve is moved by side-wall friction exerted by the enveloping sediments as you drive in or retrieve the sampler. Movement of the external sleeve causes the steel fingers on the inner brass liner to move in and out of the wall of the shoe. The fingers themselves are a very inexpensive item that you can get from a drilling supply company. If you have detailed questions about the sampler design and manufacture, I suggest that you talk with Carl as he is leading our effort in this area. His number is the same as mine.

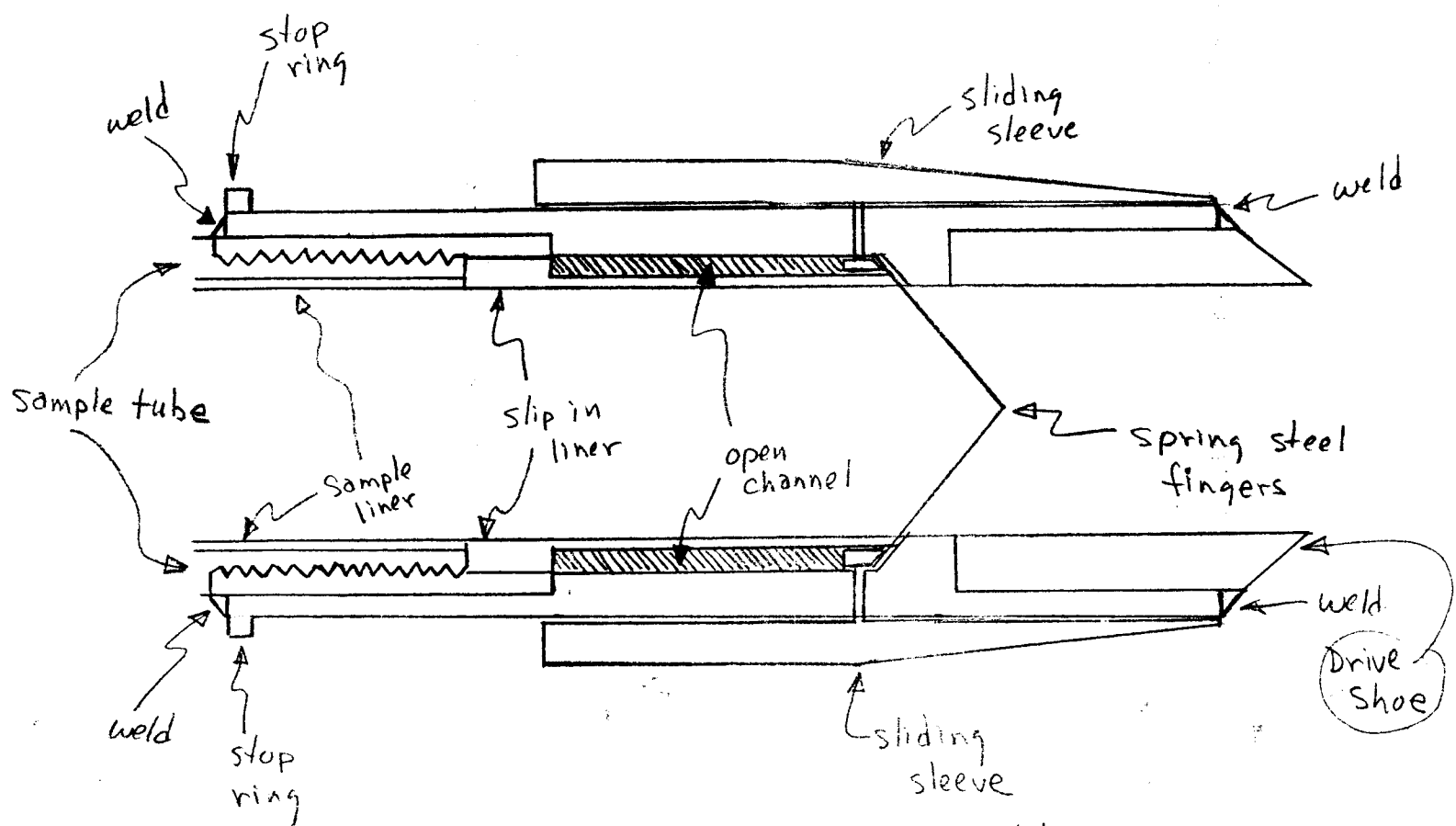
As you will note from the copy of the AGU presentation, we are also exploring other sampler designs that we think might be more reliable. Improving the sampler design is one of three areas that we will be concentrating on for the next six to nine months, so we may have some interesting news to report in the not-too-distant future. By the way, I did talk with several people from the University of Waterloo at the AGU Mtg. and found out that they currently had not done anything in this area.

Please keep us posted on your work up at Cape Cod. From talk with people in the consulting world, I have learned that there is a great deal of interest in the development of a better saturated-sand sampler. We might consider working together in this development effort. If you ever can arrange a trip to put you in the vicinity of Lawrence, please feel free to pay us a visit. We can provide lodging in one form or another.

Trust all is well in Beantown.

Sincerely,

James J. Butler, Jr.



Need 4 slots in side to let the sleeve slide.

Modification: The sliding sleeve must be long enough to cover the slots.



