Investigating Groundwater-Atmosphere Connectivity in a Headwater System

Lawrence Thompson and Robin Glas

Department of Geology, Sonoma State, Rohnert Park, CA

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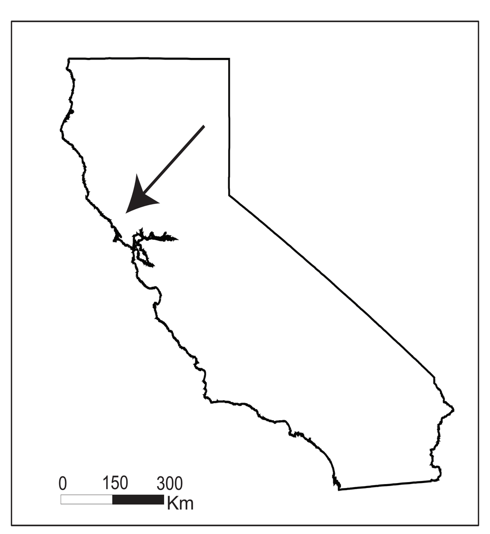
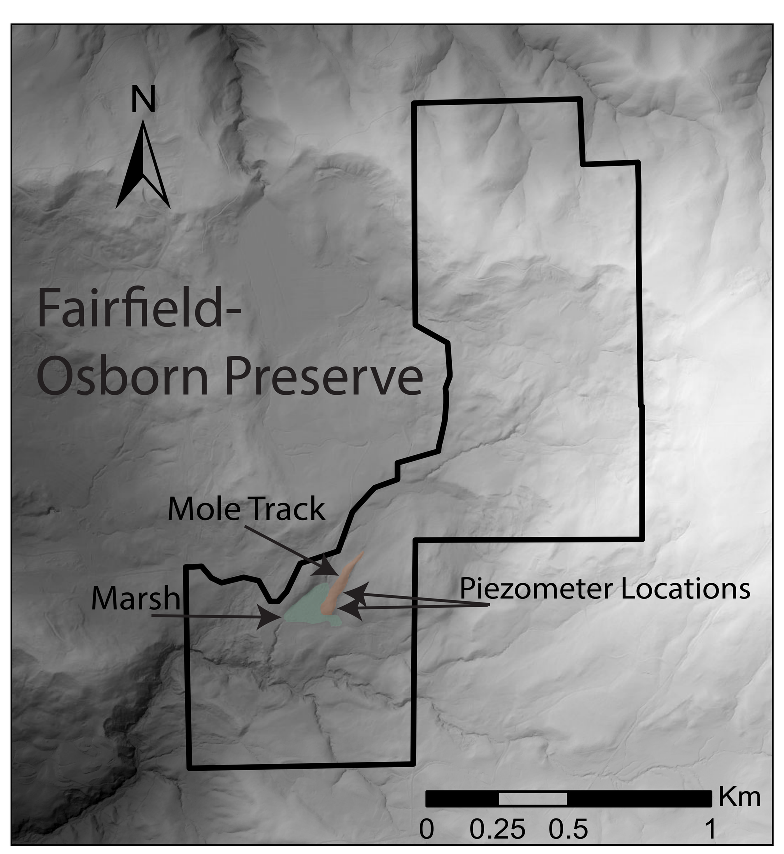
Abstract

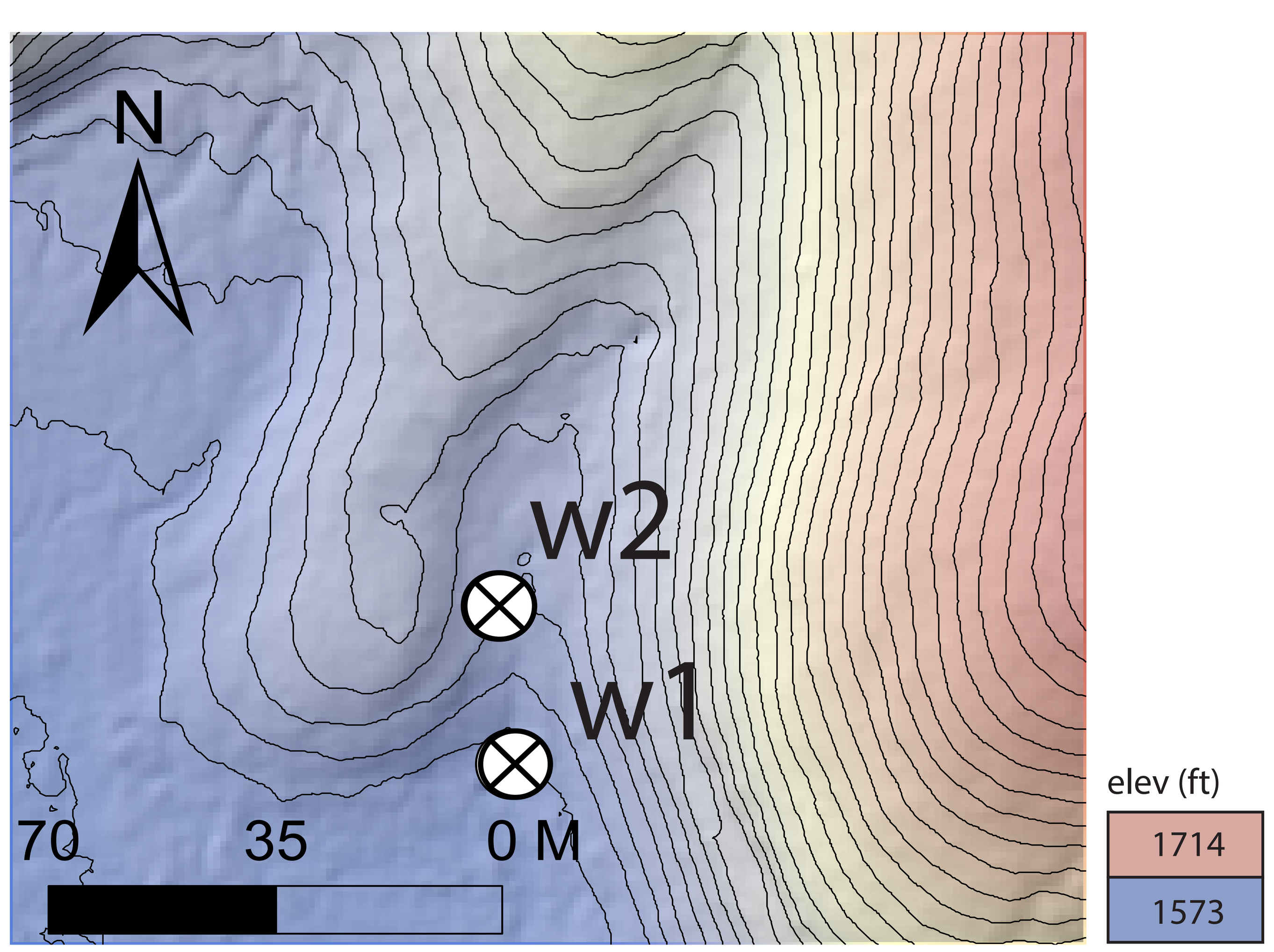
In the context of a changing climate there is a need to understand water cycling and storage in the headwaters of the Russian River watershed. In the headwaters of Copeland Creek, perennial groundwater inputs seem to be an important part of our water cycle, although the quantity and timing of water storage in this part of the watershed are not well understood. We monitored the shallow groundwater response to precipitation events near a perennial spring on the west side of a "mole track" ridge at The Fairfield Osborn Preserve. This ridge seems to have an important hydrogeologic function, and the purpose of this work is to understand how this topographical feature is driving groundwater discharge to a nearby marsh. We installed two piezometers ranging 1-1.5m deep with sand packed at the bottom. We screened the bottom 12 inches (appx.) to allow water into the well and installed a pressure transducer that is sensitive to changes in water level over time. The top 20 inches of soil was found to be organic-rich silty clay loam. This is followed by a clay that contains a smattering of poorly sorted rocks, some of which are cobble sized. About one meter down the clay becomes saturated and is darker in color. The deeper clay unit contains overpressured water, which rose upward in the piezometer after bailing the water out with a foot valve pump. Water levels were logged every 10 minutes and compared with hourly precipitation from a nearby weather station. Preliminary results show a strong response to precipitation in the shallow subsurface, with a peak delay time ranging from 1 to 3 hours, with a strong influence of antecedent moisture on groundwater peak times.

Site description

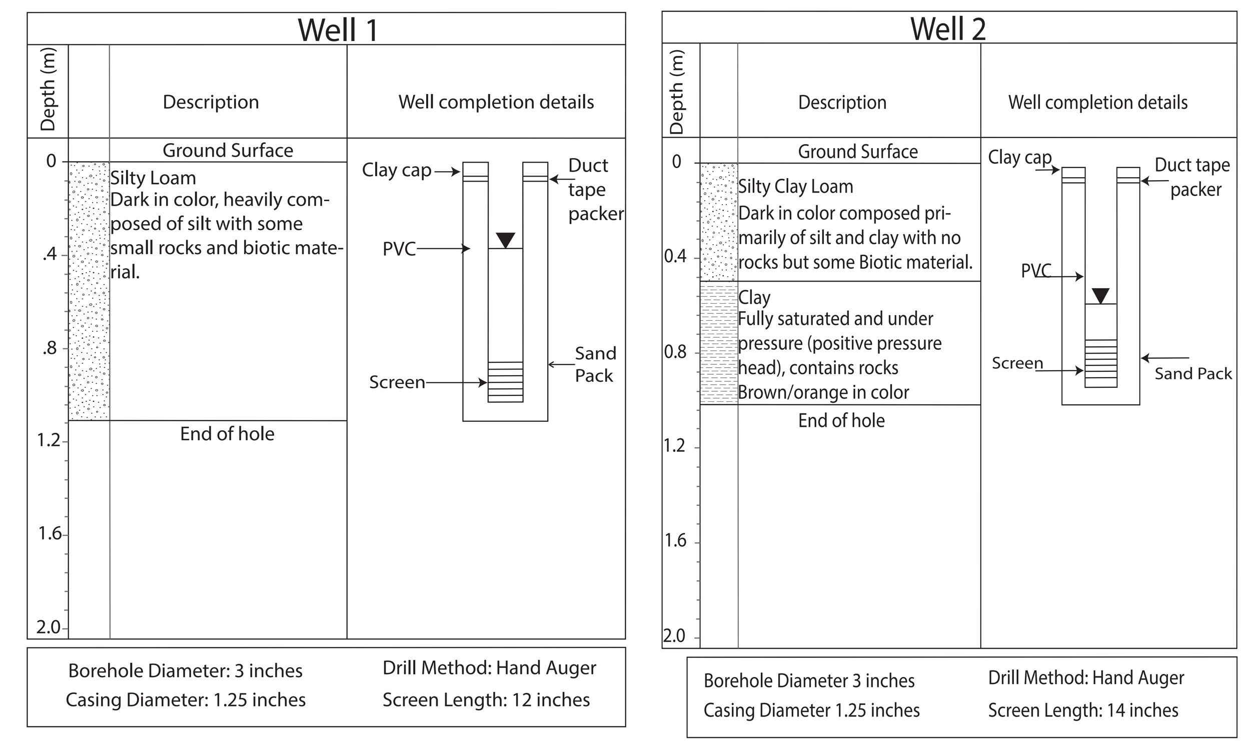




The spring emerges parallel to the mole track- wells were installed on east (w1) and west (w2) sides of the spring-fed stream, which drains into the marsh.



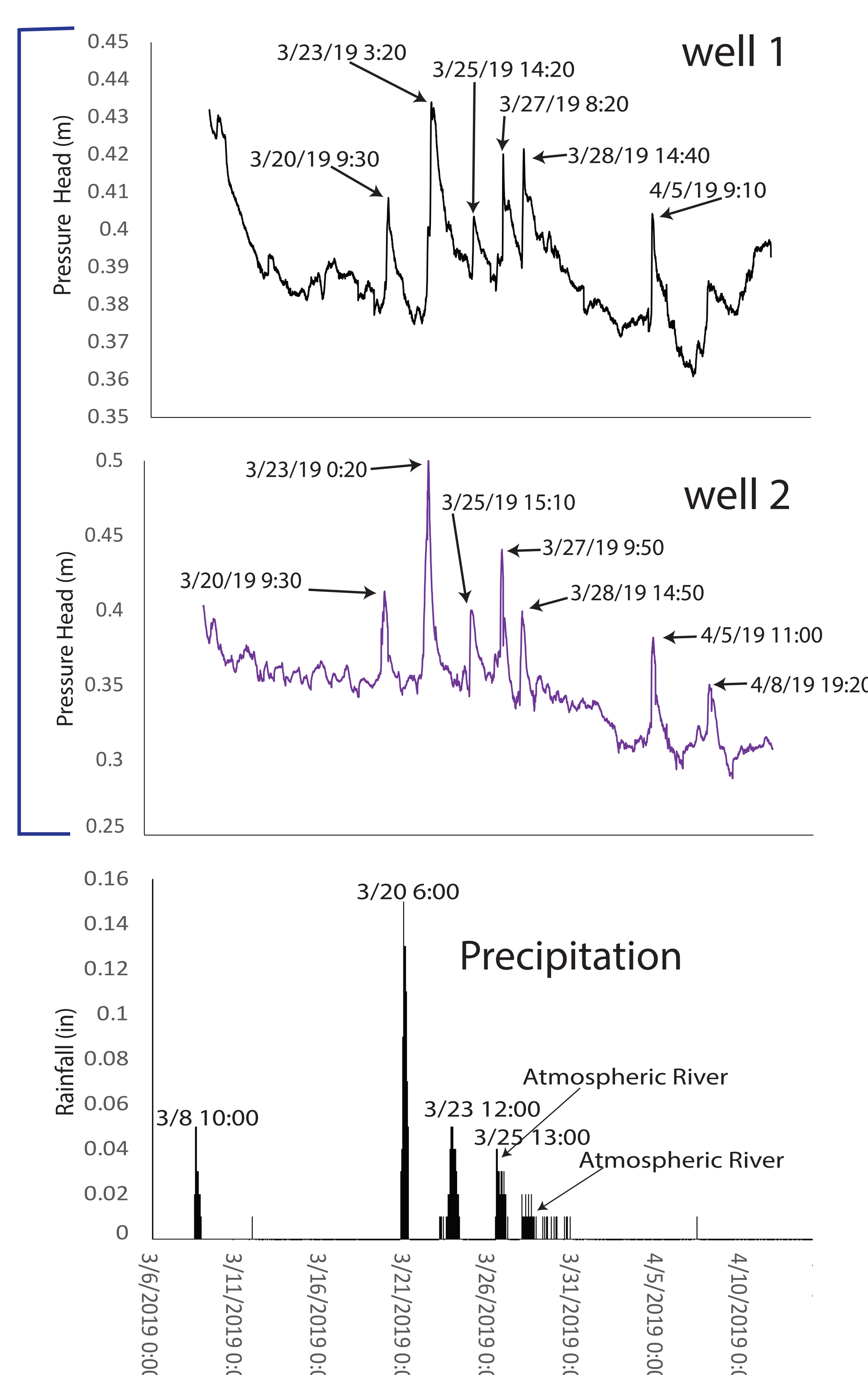
Methods



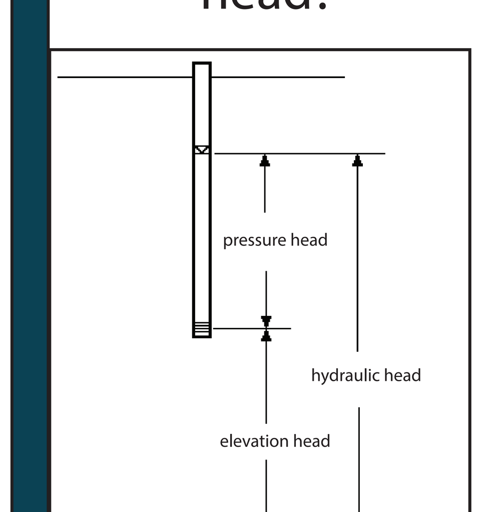
- Hand Auger used to dig ~4 inch diameter borehole radius
- Cut PVC pipe to match the depth of the holes.
- Installed 12-14 inch screen on the bottom of the pipe by drilling holes and then wrapping it with a polymer screen.
- Sand pack was added to outside of screen to prevent clogging
- One or two inches below the gound surface installed duct tape donut packer about one inch thick and cover above it with clay.
- Wells were bailed out to measure the time it took to refill so we could calculate the hydaulic conductivity of the deepest unit.
- Pressure transducer hung by kevlar chord from the well cap
- Barometer installed at surface level to subtract air pressure from the pressure transducer readings.

Response timing

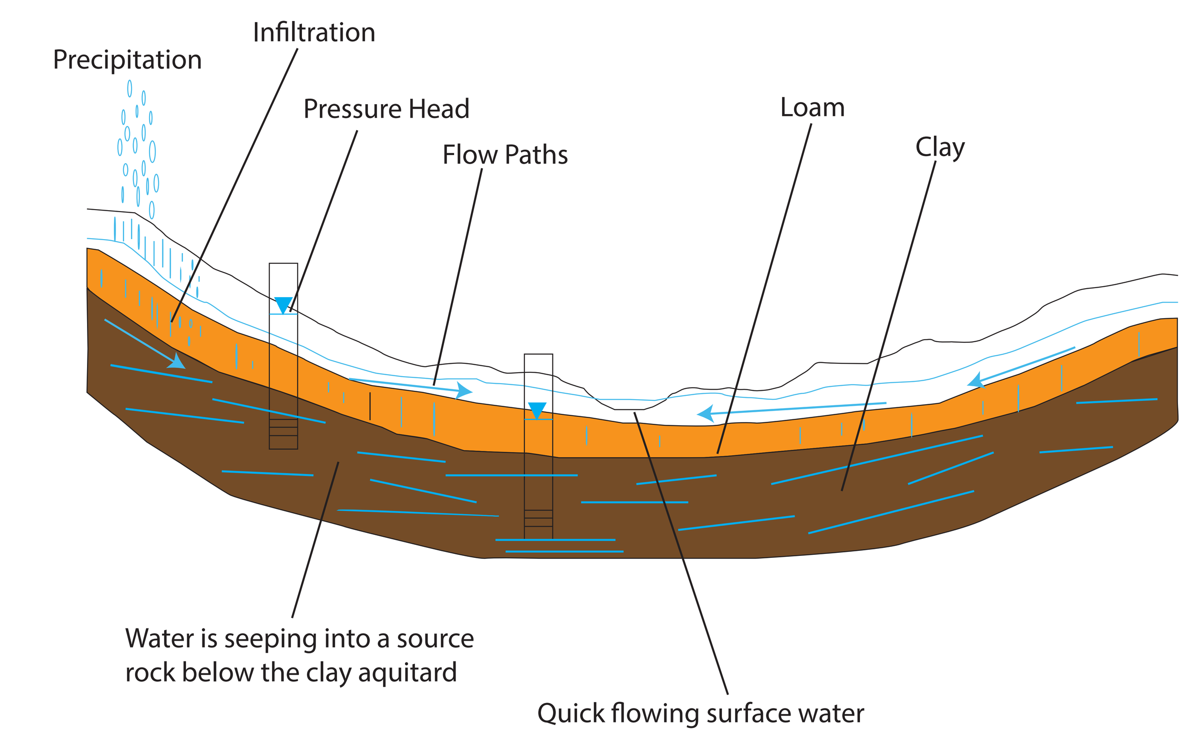
- Delay in groundwater response to precipitation
- Gradual drawdown over time in hydraulic head: wet to dry season transition
- Spikes in pressure head are not necessarily tied to storms: influence of antecedent moisture?



What is hydraulic head?



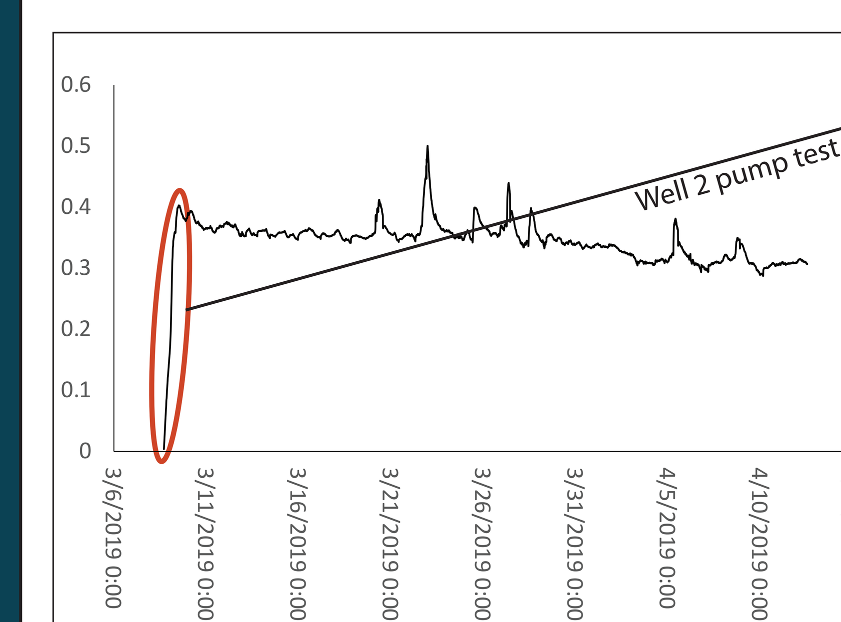
Shallow groundwater flow through porous media: Response to precipitation



Groundwater flow can be tracked by observing pressure head change over time. Water will always move from high head to low head. As the groundwater flows through, the head upgradient will be observed as higher.

Hydraulic conductivity

(How easily water moves through the subsurface)



$$K = \frac{r^2 \ln(L/R)}{2LT_{37}}$$

K=Hydraulic conductivity
T_{37}=Time for water to reach 37% of maximum height
R=Borehole Radius (estimated from auger)
L=Length of screen
r=Diameter of PVC

Well 1: $K = 1.38 \times 10^{-6}$ m/s
Well 2: $K = 3.58 \times 10^{-8}$ m/s

Deeper unit in well 2 was much less conductive than well 1: less permeable clay.
Water naturally rises in the well casing due to overpressuring at depth (artesian conditions)

Hydraulic Conductivities of common materials:
Clay 1×10^{-11} to 4.7×10^{-9} m/s
Sand 9×10^{-7} to 5×10^{-4} m/s
Gravel 3×10^{-4} to 3×10^{-2} m/s

Conclusions

- We successfully executed a pump test and determined that the hydraulic conductivity of the clay layer.
- Well 1 and well 2 are screened at two different hydrostratigraphic units.
- Groundwater response to local convective storms is stronger than the response to atmospheric river events.
- Groundwater levels also spiked in the absence of strong precipitation events. Possible influence of antecedent moisture levels.

Future work: What is the hydrogeologic function of the mole track?

- Create a detailed topographic survey of the area
- Install more piezometers to form a transect along the mole track
- Deepen our well transects so that we can see groundwater fluctuations year round instead of only during the wet season
- Run multiple geophysical surveys over the field area and the adjacent to mole track.

References

Chavez, D. (2013). Groundwater potential of pampa aquifers in two glacial watersheds, Cordillera Blanca, Peru (Master's thesis, McGill University Libraries).