A Peep at Seeps

An Independent Project
for Environmental Studies 102

by
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Introduction

Walking through the woods on a warm spring day, the adventurous visitor bravely steps off the trail and heads toward the sound of a brook. After a few minutes of carefully placing her footsteps, her attention becomes absorbed in the vegetation around her. No sooner do her eyes leave the ground, however, than she finds herself ankle deep in water, on a terrace still several meters above the stream.

Obviously, this wanderer has encountered a seep—an outflowing of subsurface water at ground-level. She must do her best to salvage her new hiking boots, and travel on her way, more careful of her step.

Now watching for wet patches, the traveller begins to notice patterns in the locations of the seepage areas. Along abandoned stream channels, water appears at intervals. Water drips from the walls of stream banks. She finds a hole in a riser to a terrace where water flows from a natural pipe.

As she walks on, her excitement grows. What could these seeps mean? Could they tell her about the geology of the land? Was there subsurface water flowing beneath her feet even now? Oh! if only she knew more!

Setting

The Rocky and Bullwinkle Plot is located in the eastern section of Hopkins Memorial Forest, in Williamstown, MA. The area is heavily wooded and is divided by Birch Brook, whose north and middle branches join in the western half of the Plot. South of the brook, the land is terraced in a series of extinct flood plains. The area's glacial history is evident in the topography and soil composition.

Geologic history. The Laurentide Ice Sheet, which covered New York state and ranged into western Massachusetts, retreated some 11,000 years ago. It left behind smoothed terrain and sedimentary deposits, widened rivers and cut channels. The meltwater ran in sheets, converged in rivers, and shaped the land in turn. After the meltwater receded, the streams cut deep, leaving abandoned flood plains as series of stair-like terraces.

The deposits left by the retreating glacier were left unsorted, as till, a matrix of particles of varying grain size. Silt & Clay particles, less than two < 1/16 mm millimeters in diameter, interspersed with larger silt, sand, and gravel 2mm = SAND fragments, together with clasts, without orientation or layering er in the matrix. This created a dense sediment layer, highly impermeable to water. These varied from stream sediments which were well-sorted into layers of grains of similar sizes. In the R&B Plot, Birch Brook left layers of gravel on many terraces, a signal of their streambed origins.

Birch Brook. In HMF, as the brook carried sediments downstream, many hydrologic phenomena were able to come into effect. Birch Brook is what is termed an "alluvial stream"[1]—its grade is low and its deposit levels are high. The brook's flow path has formed sharp curves known as meanders. At the outside of such curves, sediment is washed away by the

[1] A. N. Strahler, *Physical Geology*, Harper & Row, 1981, p. 419.

centrifugal force of the stream. The formed "cutbank" is continually eroded away by the rushing water.

Ground water. Streams represent the emergence of the "water table" above the surface of the ground. Beyond the banks, however, the water table is primarily underground. It is the theoretical line (denoted by ∇) beneath which the pore spaces between soil particles are completely saturated with

... printer problems!

water.[2] The area above the water table, below the ground surface, is called the vadose zone; there, the open pores in the soil allow water to run freely. Below the water table is the saturated phreatic zone, whose permeability is determined by the soil's sedimentary composition.

In the most basic case, the water table follows the contour of the land. "Flow lines" run perpendicular to the water table contours, converging or diverging below the ground, depending on subsurface sedimentary phenomena. Multiple layers of sediment provide more interesting scenarios, however. Often, alternating layers of permeable and impermeable materials allow several different levels of ground water, communicating with each other to various degrees. A layer of saturated material in contact with the atmosphere through pores is termed an "unconfined aquifer." A permeable or semi-permeable layer completely enclosed by other impermeable layers, allowing no communication between the saturated layer and the atmosphere, is known as a "confined aquifer." At the points at which these aquifers intersect the ground's surface, springs and seeps are formed, allowing the ground water to run at surface level. The water in an opened confined aquifer will rise to the regional level of the water table; this is known as the "piezometric surface." An area in which an unconfined body of water is

[2] Robert G. LaFleur and David J. DeSimone, *Surficial Geology and Water Resources of Hancock, Massachusetts,* p. 36.

found isolated above the general level of the phreatic zone is known as a perched water table.[3]

Findings and Discussion

Six springs were identified by the ES102 class in our topographical mapping laboratory, Feb. 27-Mar. 1, 1995. All were located in the immediate vicinity of Birch Brook—four on the south bank of the middle/main branches and two on the north branch. Several other seeps became evident in late April after the snow had entirely melted, all on the south bank of the brook. Field research for this project was conducted primarily on Apr. 26, 1995—a day which was very dry and already showed signs of spring. ...I chose to examine three of these of these seeps/sources.

Refer to your site map!

Our instruments were a shovel, a camera, and an portable pH meter for taking temperature readings. In the laboratory, samples were run to find concentrations of the exchangeable cations Ca^{+2}, Mg^{+2}, $Na^{+2}$and K^{+}, using atomic absorption spectrophotometry. The temperature and cation concentrations were extremely similar in all three seeps and the brook, with the exception of K^{+}, which had much lower concentrations in the brook than the seeps. This is probably due to the plant debris found in the soil surrounding the seeps.

Data should be here not only on poster

[3] Stanley N. Davis and Roger J. M. DeWeist, *Hydrogeology*, New York, John Wiley & Sons, Inc., 1966, pp. 43, 44.

Our main focus was a seep in the south-eastern corner of the Plot [Point 1 on the map]. Here, a cutbank has formed on the south side of a curve in the stream, a riser to the first terrace above the stream. The eroding bank is angled away from the stream in a steep vertical rise of less than three meters, exposing a mound of phyllite till. A line of seepage runs parallel to the perimeter of the mound, and the water flows down the bank into the river, increasing the level of erosion.

The line of the seepage is clear in the distribution of vegetation on the slope. Following the same perimeter is a heavy border of moss and fern-like plants, which thrive in wet areas. The rest of the slope is bare. The plants obviously grow from the wet area created by the seep. There is little or no moss on nearby banks in which no seeps are present.

The most noticeable point of seepage is on the western edge of the mound, where water flowed freely down the face of the bank, despite the dry weather. As the water has converged at this point, a groundwater phenomenon known as "piping" has come into effect. Hollow veins beneath the earth's surface have formed to act as a direct passageway for the running water. At this site, the pipe intersects the ground surface, and it is possible to reach through the water into the open pipe, which is several centimeters in diameter. The water has created such an efficient method of throughflow, that it refused to run through the piece of rubber tubing that we stuck into the open hole. The trickle that we finally captured was large enough and clear enough to drink from.[4]

The mound is composed completely of till, covered by a thin layer of biologically-enriched soil, and is azonal, which indicates the continual workings of the ~~stream~~ water; layers could not form in the constant erosion. The terrace above is composed of well-stratified layers of gravel; its age is revealed in its pillow-and-cradle topography and late-successional vegetation.

This topography suggests that a perched water table sits above the table which feeds the brook [Figure 1]. Although it is possible that this is simply a case of throughflow, the definite line of seepage, together with the obvious sedimentary composition of the mound suggests otherwise. In the case of a perched water table, we would find that a secondary, higher table is suspended by the layer of till which is evident on the rise. The water's low temperature indicates that the spring water comes primarily from precipitation, although the aquifer's ability to run in dry weather suggests a possible secondary source. If the till layer is semipermeable, there may be some communication between the perched table and the main table, which feeds the brook, in the form of leakage. However, the well-formed piped flow of the spring shows that enough water is consistently present to form a mature system in a young bank.

[4] Dave DeSimone proved to be a worthy connoisseur, and found the drink refreshing. Ha!

The geology of our second seep paints a new scenario [Point 2 on map]. This water appears in a soggy area, several meters in length, on the first terrace to the south of the brook. It is evident from the land formation that this is an abandoned channel of the brook, which now runs about three meters below. The channel is composed of gravel, further demonstrating its streambed origin.

Following the extinct channel downstream, we find several seeps such as this one, in areas where the ground is low. The topography suggests that the water table in this area runs very close to the ground's surface, and intersects it where the ground sinks to meet it [Figure 2]. When holes are dug in the immediate vicinity of the seep, which has no well-defined boundaries, water immediately fills the hole to the level of the water table. This is similar to the piezometric surface seen in opened confined aquifers.

Our third seepage area combines the prominent features of the other two in a unique setting [Point 3 on map]. It is found to the east of the north branch of the brook, on the bank and the first terrace. The terrace is located less than three meters above the current floodplain, and is over eight meters wide.

On the surface of the terrace, an area four to five meters in diameter is partially submerged in shallow water. The wet area ends more than a meter before the terrace's edge, but a shallow pit dug anywhere in the near vicinity quickly fills with water.

The riser itself is a cutbank, though not as dramatic a one as that of our first seep. Water can be seen dripping from various points along the riser, most dramatically from the exposed roots of a tree growing from the terrace above. On days after heavy precipitation a four to five meter area of the face of the rise trickles with ground water. Obviously, this is an area of high erosion, brought about first because of the brook and redoubled by the flow of the spring.

There are two possibilities for the hydrogeologic layout of this area:

1) This may represent a perched water table, very similar to our first seep. In this case, this higher water table would intersect the rise at a point high on the mound and the water would drip downward to cover the mound's surface.

2) Alternatively, there may be only the main water table, running very close to the mound's surface as it slopes downward toward the river. This would mean that in times of heavy precipitation the vadose zone on the riser would be flooded, leading to the entire surface acting as a giant seep. This phenomenon is known as "throughflow."

Given either picture of what is occuring on the rise, the understanding of the water on the terrace is the same. As in our second seep, the water table on the terrace runs very close to ground level, and is exposed in low areas in the ground's surface.

Conclusions

The commonalities between the three seeps are reflections of the Plot's overall hydrolgeology, and relate back to the formation of the land. Each of these three, as well as the other known seeps on the Plot, seems to be shallow in depth, running above the layer of till which is found along the brook's edge. The history of the Plot is visible in the springs: former channels and banks flow with groundwater. And the future is apparent as well: erosion is increased by the seeps and by the meanders of the stream.

Our wanderer is satisfied with her discoveries. She feels a sense of completion as the past and future merge with the flowing of the water. She turns back toward the trail, happier, muddier, and heads for home, knowing even as she does so how much more there is to learn.

Acknowledgments

This project owes its existence to Dave DeSimone, who first suggested it and who gallantly accompanied me to the field, dug, and drank. Many thanks go out to Deborah Brown, who let me talk it through and who taught me glacial history. Jeremy Calleros-Gauger and I exchanged findings. Mac Harman told me about temperature. Pamela Bromley taught me how to dilute water samples in the middle of the night. Sandy Brown was patient. My mother, Diane Schuster, kept me from losing sanity. Thanks to all of these individuals for your help and support.

Figure 1: SEEP #1

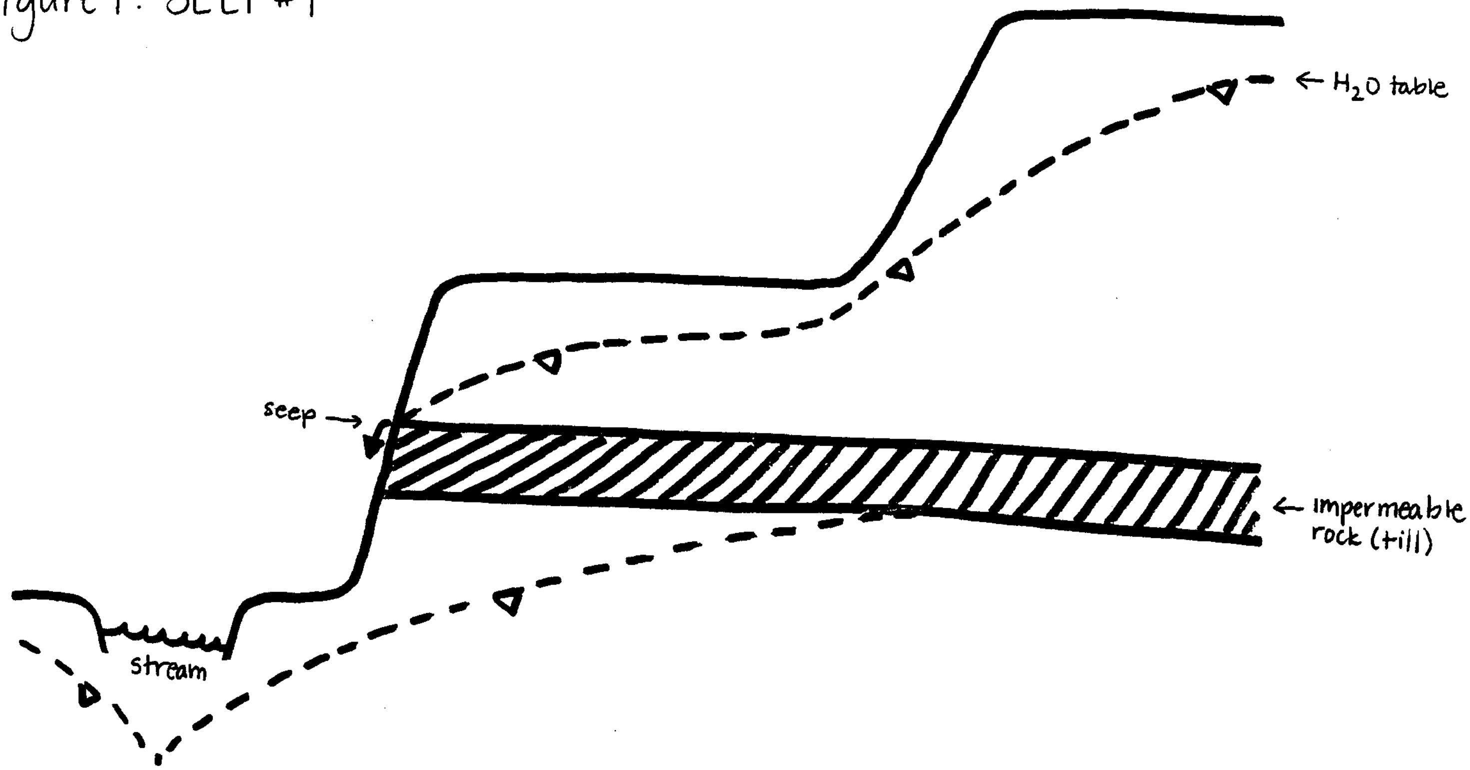


Figure 2: SEEP #2

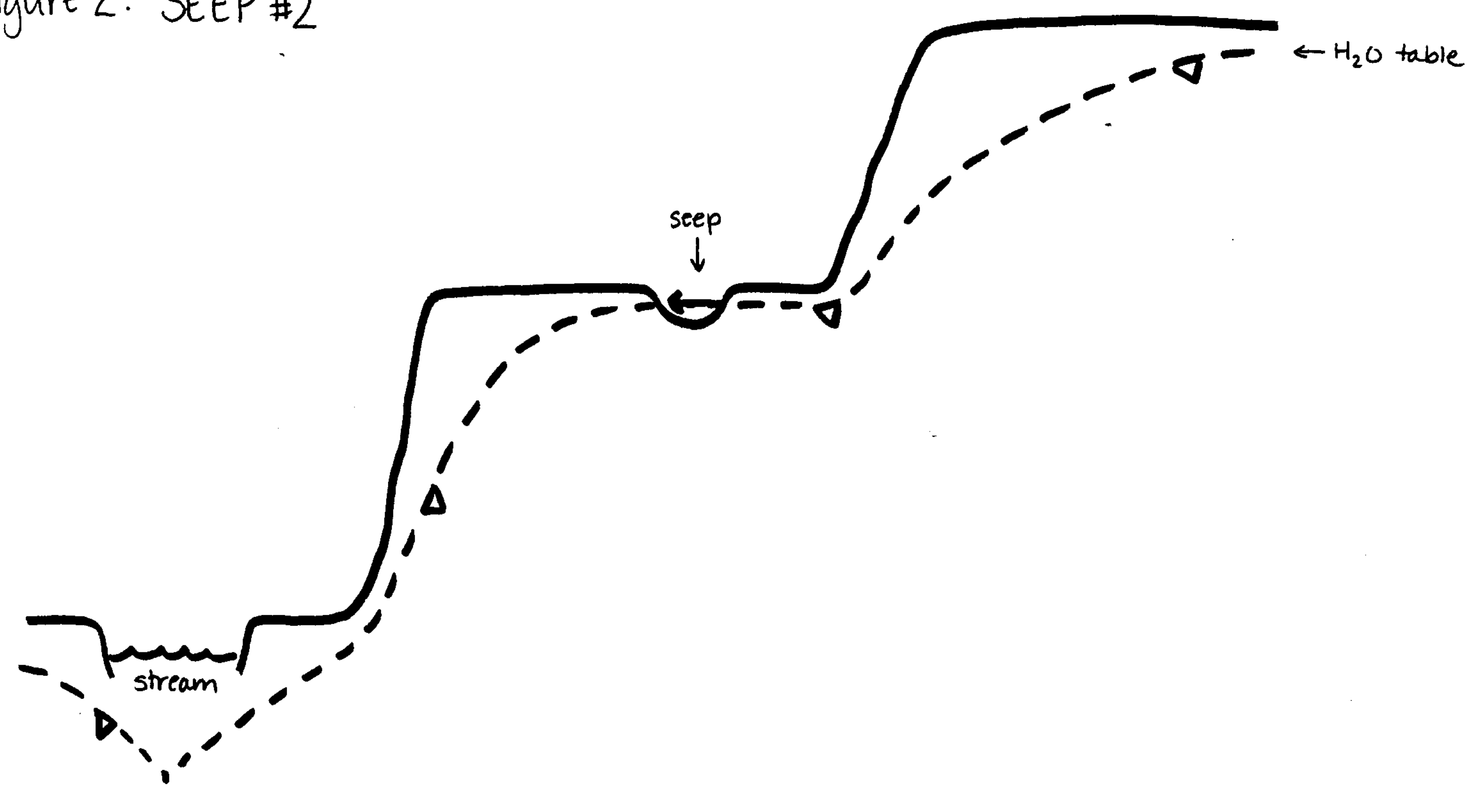


Figure 3a: SEEP #3
(1st possibility)

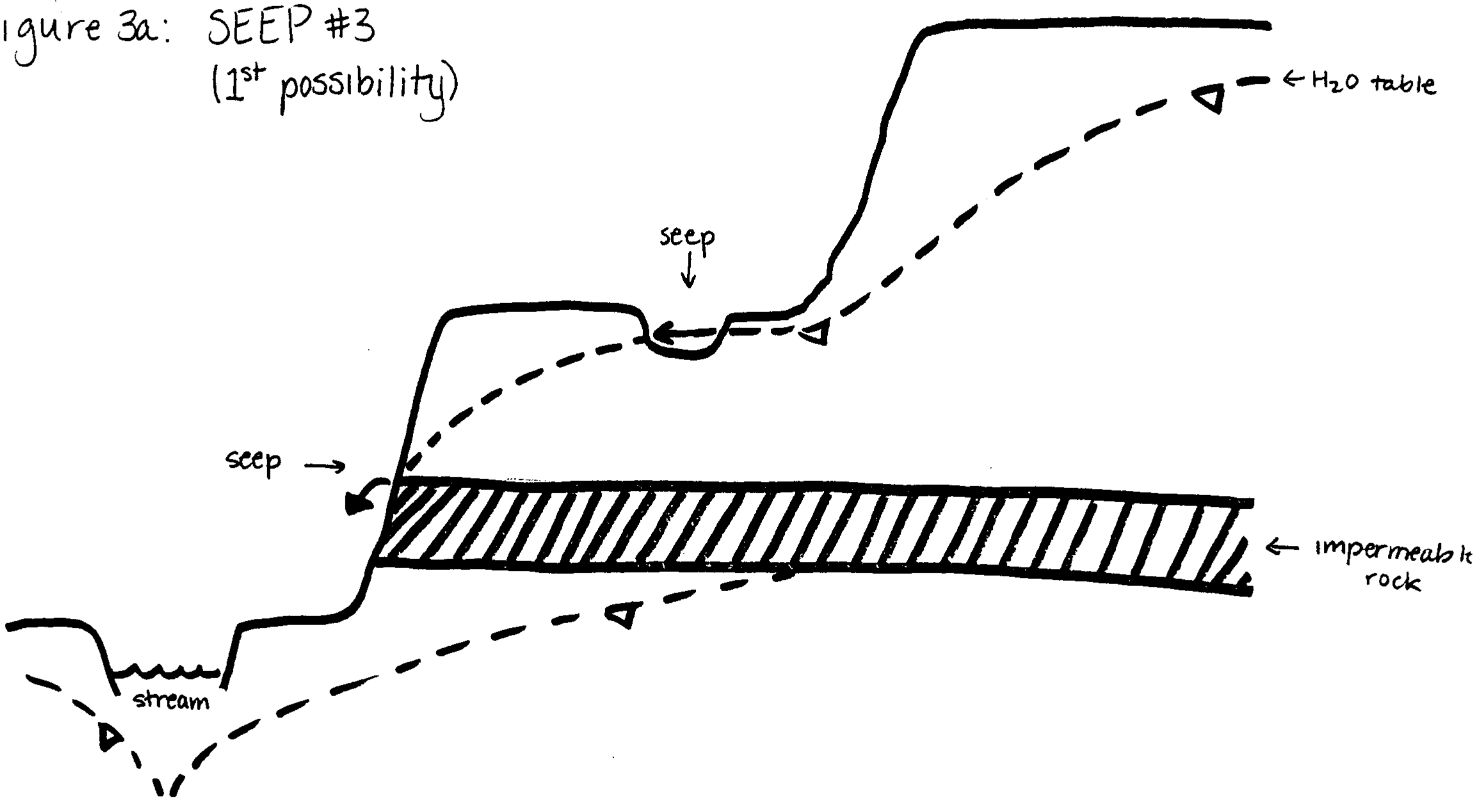
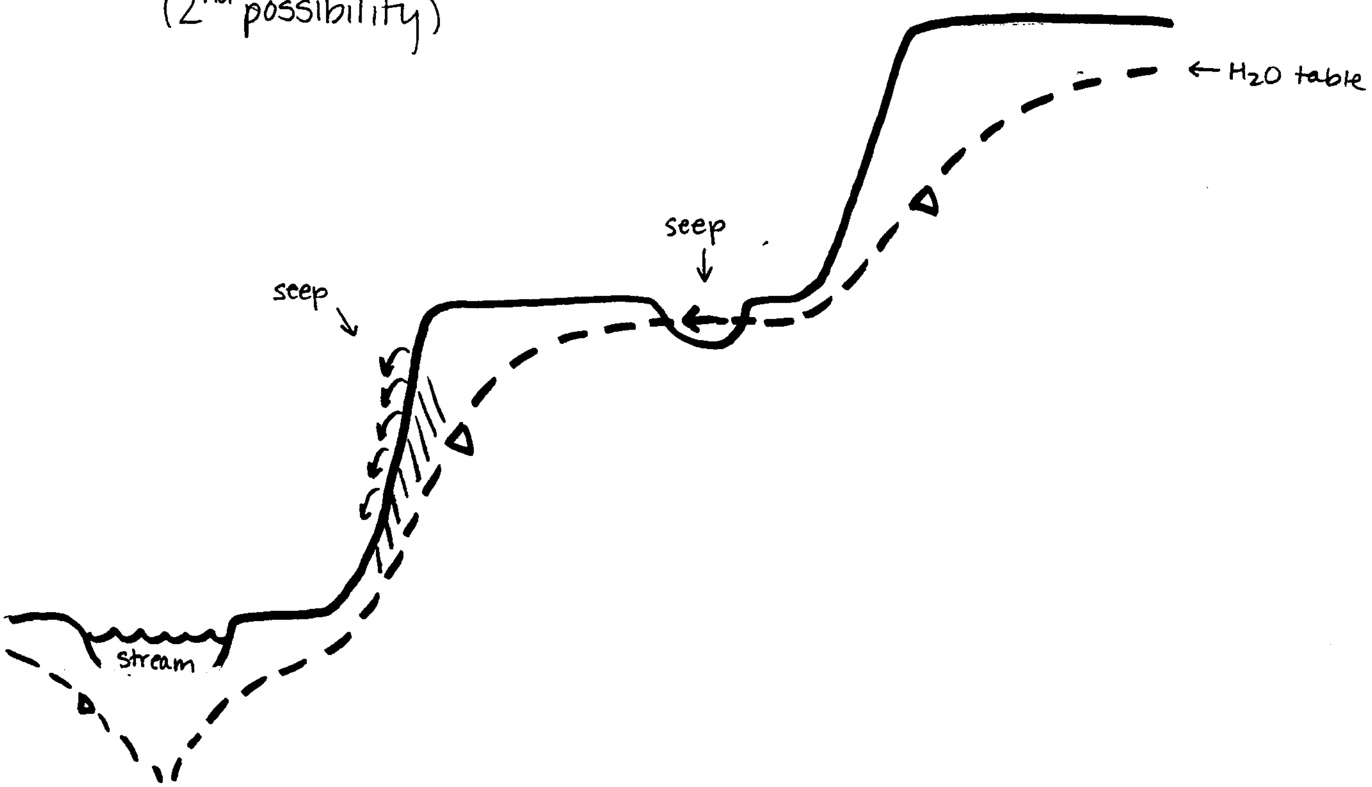
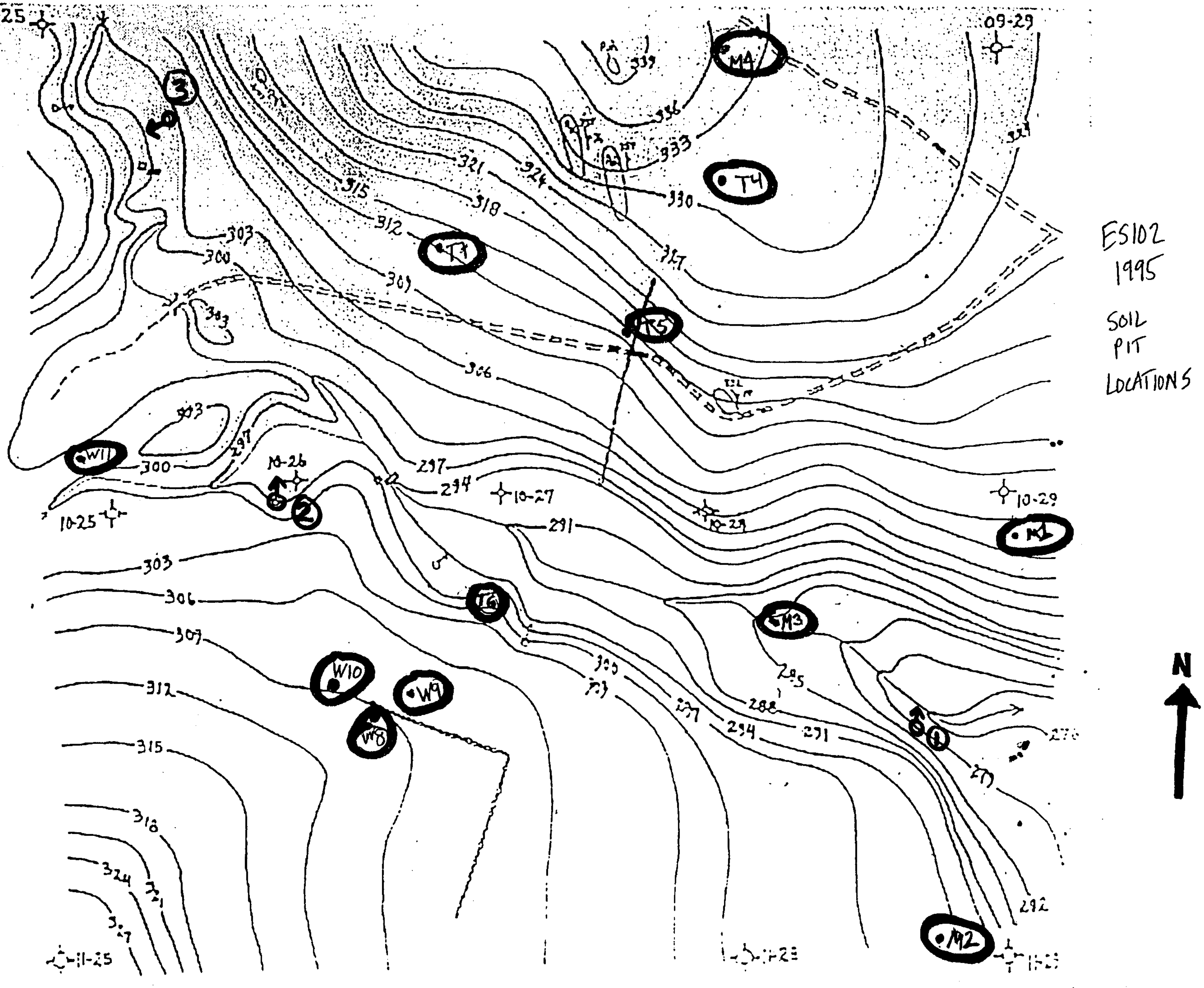


Figure 3b: SEEP #3
(2nd possibility)

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