11 Groundwater

The objective of this assignment is to use Darcy's Law and flownets to estimate the path and traveltime of a contaminant. In order to complete the lab, you need to remember a few points:

- Water flows downhill. This means that the flowpath of ground water is perpendicular to contours of the water table.
- The gradient (slope) of the water table is one of the factors controlling the rate at which ground water flows. We determine the gradient just like we did in our other topographic labs. This gradient is usually denoted $\frac{\Delta h}{\Delta l}$.
- The two other important factors that control the rate of flow are permeability and porosity. Permeability is a measure of how easily water passes through a rock or sediment—gravel has a high permeability while clay's permeability is low. Porosity is a measure of the amount of void space in a rock or sediment, usually expressed as a percentage. A typical number for a sand is 30%.
- Darcy's Law summarizes the relationship between these factors:

$$\overline{v} = \frac{-K}{n}\frac{\Delta h}{\Delta l}. \tag{1}$$

  where $\overline{v}$ is the average velocity, K is the permeability, n is the porosity, and $\frac{\Delta h}{\Delta l}$ is the gradient of the water table.

In the attached figure is shown a contour map of the water table elevation for an unconfined aquifer from which the town of Easleyville draws its water. The water supply is obtained from two wells, W-1 and W-2. A nearby town recently lost use of its wells due to benzene contamination from leaking underground storage tanks. Concerned citizens have requested that the town devise a Wellhead Protection Plan (WHPP). A first step in the process is to identify potential sources of ground-water contamination. Among the sources identified are four gasoline stations, marked A-D on the map. In continuing work on the WHPP, your tasks are the following:

1. Determine if a leak from each gasoline station is likely to reach the wells by constructing flowlines from each station.
2. Determine the travel times from each station to a well, if appropriate. Assume that the porosity of the aquifer is 25% and the hydraulic conductivity is 200ft/day. Furthermore, assume that the gasoline moves at the same velocity as the water.

(a)

(b)

(c)

(d)

3. Gasoline in fact travels much slower than the ground water, perhaps at half the rate. How does this affect your calculations?

4. If a spill (any contaminant, not just gasoline) took place at the road intersection shown on the map and the contaminant entered Hampton Creek, then

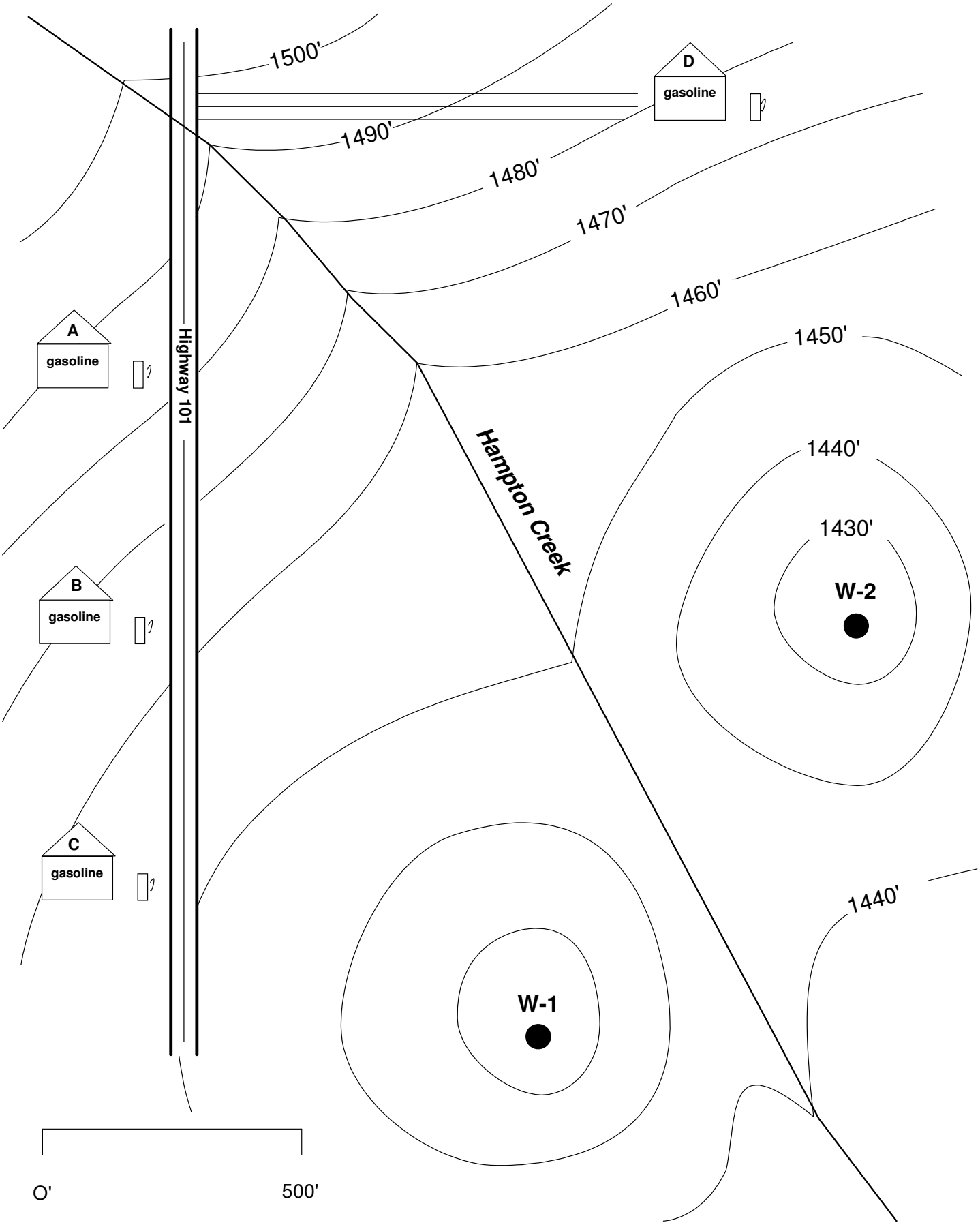
   - What is a property of the contaminant that might be important to consider?

   - Would that contaminant enter the ground water? Why or why not?

   - Label the parts of the stream gaining water from the ground water and the parts losing water to the ground water.

5. Consider how a groundwater well is constructed, open or screened at the bottom. Gasoline is less dense than water and not very soluble. How does this affect the likelihood of gasoline contaminating the wells? Think of at least two effects.

6. If you discover that well W-1 is already contaminated, what would you suggest as a management scheme for supplying Easleyville with water. What additional information might you want?


1500'
1490'
1480'
1470'
1460'
1450'
1440'
1430'
1440'
D
gasoline
A
gasoline
B
gasoline
C
gasoline
Highway 101
Hampton Creek
W-2
W-1
O'
500'

Out-of-Class Assignment

Write up your management plan for the last question. Be sure to include a list of priority users, emergency plans, and recovery plans. Submit it at the beginning of lab next week.