Lab #2

Materials:
- two adjacent topo maps showing the Pine Tree Brook Watershed – 11" X 17"
- xerox of a topographic map of the Pine Tree Brook watershed – 11" X 17" piece of velum tracing paper – 11" X 17" piece of 1 inch by 4 square graph paper – sheet of white paper – sheet of lined paper – lead pencils, blue pencils, eraser and ruler – calculator – graph paper or access to Excel

Neponset River Watershed Association, 2010
Exercise 1. The Watershed Demonstration Model:
We’ve built a fiberglass watershed model for a mountainous region similar to the White
Mountains of New Hampshire. By ‘raining’ on the model, we’ll be able to demarcate the
watershed(s).

1. **How many major watersheds can be seen?**

An average of 3 main ones. I will call them WS1, WS2 and WS3 for better reference.

2. **How many sub-watersheds does each of the major watersheds have?**

   - WS1 has one sub-watershed
   - WS2 has two sub-watersheds
   - WS3 has one sub-watershed

3. **Are any of the major watersheds or sub-watersheds totally enclosed in this model (i.e. can you fully delineate the boundaries of either a major watershed or a subwatershed)? Explain.**

   According to my notes there are no areas with complete isolation. With enough rain
pour even the most separated areas WS1 and WS3 can be connected. The elevation of the
surrounding topography can provide some boundaries with low amounts of water poured
into that specific area.

4. **How did you deal with the monadnock? Does it exist within a watershed, or does it lie on the boundary of a watershed? Explain.**

   It lies between boundaries of watersheds. Situated close to the center of the model, it
divides the waters into different locations.

5. **Draw a diagram of the model, filling in the boundaries of the major watersheds and sub-watersheds that you can discern, and label each of the major watersheds and subwatersheds. Orient your diagram with North at the top of the page. USE A PENCIL, IN CASE YOU NEED TO MODIFY YOUR DRAWING!**

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Exercise 2. Delineating the Pine Tree Brook watershed:
1. Follow the directions in the NRCS handout and delineate the Pine Tree Brook watershed. Each student should take one of the 11" X 17" color xeroxes of the topographic map that contains the Pine Tree Brook watershed, and an 11" X 17" piece of tracing paper.

2. After studying the topo map, what is your vantage point for delineating the Pine Tree Brook watershed?

I have circled the vantage point at the Boston Corp. Body, north of Milton Village.

3. An easy way to begin to see which areas are part of the Pine Tree Brook watershed is to tape the top edge of the piece of tracing paper to the xeroxed topo map. Starting with your vantage point, trace all the brooks, streams, ponds, lakes, etc that are upstream of your vantage point and are connected together. Use a blue pencil so that you can easily erase any mistakes.

You may need to periodically flip up the tracing paper so as to better see the details of the topo map. You will end up with a large, “tree-like” diagram of all the water bodies within the Pine Tree Brook watershed.

4. Now that you can see what water bodies are inside the Pine Tree Brook watershed, you can more easily determine where the outer edges of the watershed are. For this part of the exercise, it is easiest to mark directly (using a pencil) on the 11" X 17" reproduction of the topographic map. (If we were using an actual topo map, we would not want to write directly on the map, but would do all of our work on the tracing paper. However, it will be much easier for you to follow the contour lines if you work directly on the reproduced map).

4. After you have penciled-in the watershed boundaries, trace your boundary lines onto the tracing paper.

Exercise 3. Measuring the area of the watershed:

1. Take your piece of tracing paper with the Pine Tree Brook watershed and place it over a piece of 11" x 17" graph paper with a 1 inch = 4 units layout. Tape it in place.

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2. Count the number of squares that are covered by the watershed. For squares that are only partly covered, count the square as “1” if more than half the box is covered by the watershed, and count the square as “0” if less than half the box is covered by the watershed. Since actually counting all the squares is tedious, you might find it easier to use your ruler – every inch along the ruler = 4 squares.

3. Calculate the fraction of a km2 that the area of each square represents: _1.609 km_.

4. Calculate the total km2 in the Pine Tree Brook watershed:
An average of 9 kilometers for the perimeter that I measured in the lab and from my research online I got an area of 19.6 km².

Q. Would your calculated area have been the same if you had used the “1 inch = 5 units” graph paper? If you had used “1 inch = 1 unit” graph paper? Would the “1 inch = 4 units” paper given you a more accurate result or a less accurate result than the other two types of graph paper? So, why did the instructions specify the use of “1 inch = 4 units” graph paper?

The larger the unit scale, the more precise answer you can extract from the graph paper. In this case the provided unit gave us the above counting and thus giving us a pretty good standard for the delineations.

The instruction specified 1 = 4 for the current exercise, to perchance facilitate the measurement in the restricted lab time provided and much harder to estimate.

Exercise 4. Calculating an annual water budget for the Pine Tree Brook watershed:

A simple, annual water budget for a watershed can be calculated based on the following formula: \( P - ET = Q \)

After thoroughly reading the assignment, one must notice a few facts. Firstly, there is graphic data ranging from 1820 to 2006, regarding both temperature and precipitation registered at a nearby reliable location: the Blue Hill Observatory. Secondly, the class was also provided with two tables ranging, this time, from 1949 to 2005, registering streamflow for the location desired and precipitation data, both to the precision of hundredths.

Since no light was shed regarding to which year the first two questions refer, the year 2005 was chosen as reference.

It is important to notice that unit conversion will be necessary, provided the answers are wanted in the metric system, in cubic meters per year. Therefore, the conversion factors that will be entered in an Excel spreadsheet will be as follows:

\[
\begin{align*}
1 \text{ cubic feet (cf)} & = 0.028316847 \text{ cubic meter (m}^3) \\
1 \text{ year} & = 31,557,600 \text{ seconds}
\end{align*}
\]

Thus, \( 1 \text{ cubic feet per second (cfs)} = 0.028316847 \text{ cubic meter per cubic feet (m}^3/\text{cf}) \times 31,557,600 \text{ seconds per year.} \) Crossing out the units leaves \( 0.028316847 \times 31,557,600 \text{ m}^3/\text{year.} \) For practical purpose, the conversion factor used will also be rounded to the hundredth: \( 1 \text{ cfs} = 1 \times 893,611.73 \text{ m}^3/\text{year.} \)
In order to obtain the annual precipitation in terms of volume, that is, m³/year, from the given unit of cm/year, one must first transform cm in meter, merely dividing the number by 100. The following step is to obtain the area of the watershed, which was not provided.

An extensive internet research resulted in the following text:

*Unquity Brook and Pine Tree Brook (Milton)*

*These sites were originally sampled in 2007 and were chosen for follow-up sampling. Some sampling locations were chosen based on recommendations from the Neponset River Watershed Association.*

**Sub-watershed Description**

- Pine Tree Brook is a tributary of the Neponset River, while Unquity Brook becomes Gulliver Creek, another tributary of the Neponset River.
- **The Pine Tree Brook sub-watershed is 7.6 square miles in area** and the Unquity Brook sub-watershed is 1.4 square miles.
- Landuse in the Pine Tree Brook sub-watershed is characterized as follows: Forest 46%, Residential 42%, Other 7%, Open Space 4%, Wetland 1%
- Landuse in the Unquity Brook sub-watershed is characterized as follows: Residential 68%, Open Space 16%, Forest 13%, Commercial 2%, Other 1%
- The section of the sub-watersheds near the study sites is generally residential. Unquity Brook is culverted underground at multiple locations.
- Pine Tree Brook and Unquity Brook are listed as impaired for pathogens on the 2006 303(d) list.
- The Town of Milton is a NPDES Phase II community, with 92% of the population on the sewer system and 8% on septic systems.
  - Google research information source

In possession of that information, the next step is to convert the area from square miles to square meters:

**7.6 square miles = 19,683,910 square meters**

The following step is to do the actual math, that is, to find ET by subtracting the streamflow (Q), in m³/y, from the precipitation (P), in m³/y. For this, I will use the red column in the Excel spreadsheet for Q, and the blue column for P, as they are already calculated in the unit required.

Now that the Excel table is finally complete, the answers are as follows, to the precision of a liter (or one dm³):

1. \( P_{(2005)} = 33,106,369.229 \text{ m}^3/\text{y} \)
2. \( Q_{(2005)} = 10,222,918.191 \, \text{m}^3/\text{y} \)

\( ET_{(2005)} = 22,883,450.038 \, \text{m}^3/\text{y} \)

Other questions presented in this exercise:

**Q1. Would you expect ET to vary monthly? What might cause this variation?**

I would certainly expect ET to vary along the period of a year, as the climate has a strong influence in this parameter. I do not have any monthly data to confirm this, as such information has not been provided. Nevertheless, one may infer that this variation exists, by looking at the yearly variation itself.

If either \( P \) rises or \( Q \) decreases in a given year, it is expected that ET will increase. Alternatively, if \( P \) decreases ou \( Q \) rises in a given year, one expects ET to decrease. Now, looking at the \( Ps \) and \( Qs \) in the table, what may have caused this variation?

The Earth assumes different positions in relation to the sun along the year. Its tilted axis proportionates the seasons of the year and variations in the atmosphere such as winds. Most of the planet’s evapotranspiration happens in the oceans, due to the great surface of water that we have, the winds and the incidence of solar radiation. There is also ET in land, due to these same factors added to soil humidity evaporation and plants transpiration. A great portion of evaporation from the oceans will be transported by winds in the atmosphere and will eventually fall in land.

Therefore, monthly variation in evapotranspiration is certainly expected, as the climate conditions that cause this phenomenon are also variable.

**Q2. Does \( Q \) directly relate to \( P \)? Why or why not? Draw a graph that depicts this expected relationship (the easiest way of doing this is to enter the data into an Excel spreadsheet and graph the data as an Excel figure). Append the graph to your lab report. Are there any other factors that could effect \( Q \) other than \( P \)?**

From the graph it is possible to notice that the precipitation \( P \) influences \( Q \) directly. This influence does not occur in the same proportion for all years, which leads to the conclusion that there must be other phenomena influencing \( Q \). That would be probably the aspects that have not yet been considered here, such as infiltration, soil capacity to retain water and conformation of the terrain (sloped areas, etc).

**Q3. What year had the least precipitation? How did that affect streamflow and ET?**

The year that had the least precipitation was 1965, which led also to a decreased streamflow and the lowest evapotranspiration, since there wasn’t as much water to be evaporated in comparison to other years. The climate has its part as well.
Q4. What year had the most precipitation? How did that affect streamflow and ET?

The most precipitation happened in the year of 1998. The line of reasoning follows that of the previous question, only in the opposite direction, since the most precipitation led to an increase in the streamflow and also produced the highest ET. This happened due to the same factors already mentioned in Q3.

September 29, 2010