What Does Stream Flow Tell Us?

Chicago River Classroom Activity

Summary

In this lesson, students will examine historic stream flow data to understand how stream flow has changed over time. Students will then hypothesize what has caused this change and attempt to graphically correlate cause and effect.

Background

Stream flow is the integrated response of a watershed to precipitation. Relatively constant watershed characteristics, such as watershed size, shape, and land slope influences how stream flow changes in response to a storm. However, it is through changes in land use that people influence how a stream responds to a storm.

In particular, land use activities affect storm flow and flood potential in the following ways:

1. Removal of vegetation or conversion from plants with high to low annual transpiration losses (such as replacing a forest with a lawn) can increase storm flow volumes and the magnitude of peak flows (the maximum stream flow during a storm period).

2. Activities that reduce the ability of water to infiltrate into soils, such as intensive grazing, road construction, and heavy logging, can increase surface runoff. As the proportion of precipitation running off the land surface increases (and the proportion infiltrating into the soil decreases), stream flow responds more quickly to precipitation events, resulting in higher peak flows.

Grade Level: 9^{th} – 12^{th}

Duration: 2-4 hours, though some can be assigned as homework.

Objectives:

1. Students will understand how changes in land use affect stream flow.
2. Students will practice using graphing techniques to solve problems.

Materials:

- Stream data from United States Geologic Survey at http://water.usgs.gov/nwis/sw
- Internet access, optional, will allow students to search for their own data to correlate with the stream flow data, otherwise, you will need to provide the data

Standards:

11.A.4a, 11.A.5a, 11.A.4d, 11.A.5d, 11.A.4e, 11.a.5e, 11.A.4f, 17.C.5b, 17.D.4, 10.A.4a, 10.A.5, 10.A.4b, 10.B.4, 10.B.5

NGSS:

HS-ETS1-1, HS-S-ID.1-4, HS-S-IC-6, HS-ETS1-3; RST.11-12.9, HS-LS4-5

1. The development of roads and ditches along with channelizing stream channels can change the way water travels through the watershed. Usually peak discharge is increased because the speed at which water travels through the watershed and down the stream is increased.

2. Increased erosion and sedimentation can reduce the capacity of stream channels. Flows that would have stayed within the stream banks may now flood.

The influence of land use is minimal for extremely large precipitation events that usually are associated with major floods. For events other than extreme ones, a stream's response to a storm changes in relation to the severity of the changes (from pre-settlement vegetation) and the percentage of the watershed area affected.

Procedure

Engagement

Ask the students if they have ever experienced a flood. If no one has experienced one directly, ask them if they have heard of any floods. Ask students what happens during a flood. Ask them why we have floods and if they think our rivers have always flooded or if they think people contribute to flooding.

During this time, you want to ascertain whether or not your students understand the concept of a watershed. They should understand that the water flooding the banks of a river is coming not just from the water falling directly on the river itself, but from the rain that is falling on the river's entire watershed. Water is carried to the river in a variety of ways: through the soil, over the soil, or over paved ground and through sewers.

If the students are unfamiliar with these concepts, take some to explore these issues with your students. If they are very unfamiliar with the concepts, you can first do the Tree or Street – Does it Matter? lesson. If they are somewhat familiar, you could have the students examine some hydrograhs, noting how water reaches a river over the period surrounding a storm. Hydrographs of actual Illinois rivers are available at http://il.water.usgs.gov/nwis-w/IL. Choose a county, then choose a stream monitoring station and then choose to view real time data for that site.

Once the students understand the concept of a watershed, tell them that they are going to examine data from the Chicago River Watershed to explore the question of flooding.

Discovery - Overview

There are many ways this lesson can be taught. In general, the lesson should have students:

1) graphing historic data from one or more locations in the Chicago River watershed
2) describing any trends they see in the data
3) generating hypotheses as to why they are seeing these trends
4) graphing one hypothesized cause of the change in river flow against actual historic river flow
5) deciding, based on their graph, whether they think that their hypothesized cause is a factor

If your classroom has internet access, you can have students go on-line and collect and download their own data. Otherwise, you will have to go on-line and collect the data for them. The stream data is readily available from the United States Geologic Survey (see below for details). Whether data is available on the cause of the change in flow the students come up with, will depend on what they choose. In some cases, students may need to think of a proxy. For instance, population estimates for Cook and Lake Counties are included with this lesson. They can be used as proxies for other causes, such as the amount of impervious surfaces. A question you can ask your students is how good a proxy they think it is? None are perfect, have them identify what some differences might be.

Historic Stream Flow Data

The United States Geologic Survey (USGS) has historical stream flow data for streams and rivers in the United States. Data is available for viewing or downloading at http://water.usgs.gov/nwis/sw. It is up to you which sites you use. In general, the sites with longer records will yield more interesting and pronounced results. All students could investigate a site close to the school. Alternatively, different groups of students could investigate different sites, and then as a class they could compare the results and investigate what might have causes any differences they observed. You could also have the students compare the Chicago River to other rivers in the US.

USGS offers its historic stream flow data in a variety of formats: daily, monthly, annual and peak. Daily, monthly and annual stream flow values are the mean (average) flow recorded during that period. Peak flow, on the other hand, is the highest value recorded at that site during the year. Peak flow can be looked at to examine high flow periods (potential flood periods). In addition, USGS offers the data in numerical or graphic format. Using the numerical data to create a graph is a good exercise in graphing and will better familiarize the students with the data. However, in some cases the sheer amount of data (particularly for daily values) may be overwhelming.

The following is a list of the river gauges in the Chicago River watershed that have data from the middle of the 20th century to the present:

USGS Code	River Name	Gage Location	Dates Available
0553500	Skokie River	Lake Forest	1951-1999
05535070	Skokie River	Highland Park	1967-2000
05535500	West Branch of Chicago River	Northbrook	1952-2000
05536000	North Branch of Chicago River	Niles	1950-2000
05534500	North Branch of Chicago River	Deerfield	1952-2000
05536995	Chicago Sanitary & Ship Canal	Romeoville	1984-2000
05536290	Little Calumet	South Holland	1947-2000
05536290	Little Calument	Harvey	1916-1933
05536270	North Creek	Lansing	1948-2000
05536275	Thorn Creek	Thornton	1948-2000
05536210	Thorn Creek	Glenwood	1949-2000
05536210	Thorn Creek	Chicago Hights	1964-1979
05536255	Butterfield Creek	Flossmoor	1948-2000
05536235	Deer Creek	Chicago Hights	1948-2000

Correlation

If students don't have a sense for what is causing the trends they are noticing, have them think about what other changes have happened during the time of record. You could also have them complete the Tree or Street – Does it Matter lesson by Friends of the Chicago River in which students investigate the effect of land use development on stream flow.

Students will be taking the stream flow data and graphing it against a factor they think may have caused the change in stream flow. They will then be looking to see if they see any correlation. To see a correlation, the line does not have to be straight. It could be exponential; it could be parabolic. But, they should be able to detect a trend. This is a very basic and rudimentary look at correlation, but should serve to introduce the students to the idea. The more random their points look, the less correlation there is and the less of a significant factor their chosen cause is. For more advanced students, you can have them either manually or by computer calculate the best fit line and standard deviation.

When doing correlation work, it is important that the two sets of data they are comparing are similar. If one is yearly data and the other daily, they can not be compared. In some cases, students may need to go back to the stream flow data and choose a different measurement that can be better correlated with the other data they have.

One possible item students may try to correlate the stream flow data to is population. Here are some good sites for county population data through the years:

- For county population data through 1790 – 1970: http://fisher.lib.virginia.edu
- For county population data 1970 - present: http://recemter.tamu.edu
- For county population data from the last decade: http://www.centsus.gov/population/www/estimates/countypop.html
- For county population data from the most recent year available: http://quickfacts.census.gov

Here is the data from the above sites for Cook and Lake Counties, IL:

	Cook	Lake
1950	4,508,792	179,097
1960	5,129,725	293,656
1970	5,493,769	382,638
1980	5,253,628	440,387
1990	5,105,044	516,418
2000	5,376,741	644,356

Wrap-up

Have the students present their findings to the class. Having each group make a poster presentation of their data may be a good way to convey the information they have found. They could then give an oral presentation to the class, or give the class time to view the different poster presentations on their own.

Extension

After the students complete their correlation work and understand some of the factors which have changed how the stream responds to rain storms, have the kids investigate what some of the consequences of these higher flows are. Have them think of both human (such as flooding) and ecological (such as increased erosion and subsequent sedimentation) consequences.