# Comparison of Five Michigan Streams

Over the course of this lab, we spent time studying the characteristics of five streams in Michigan. The first two streams we studied, Fleming Creek and Mill Creek, are located in southeastern Michigan. The final three, the Maple River, the Oden Fish Hatchery, and the Pigeon River, are located in the northern portion of Michigan's Lower Peninsula. These streams vary in drainage area, land use in their watershed, and surficial geology. The way these characteristics interact in each watershed determines features such as the discharge of each stream, the water chemistry, and the in-stream habitat which in turn impact the biology that are able to live within a particular stream. Once these characteristics of a stream have been identified, they can be used to explain the differences observed between various stream systems.

The land use in a watershed has an impact on the amount of discharge in a stream, the fluctuations in discharge we see in the channel, and the chemistry of the water. The Maple River and the Pigeon River are predominantly forested watersheds while Fleming Creek is mostly forest with some agriculture and Mill Creek is primarily agriculture (Figure 1). We expect forested watersheds to be baseflow driven systems because forests provide a constant pervious surface for rainfall to infiltrate down to the water table and enter the stream as baseflow. Conversely, we might expect agricultural and urban watersheds to be driven by runoff because their surfaces are less likely to be pervious and rainwater is more likely to enter the stream through storm sewers, field tiles, or over compacted ground. We found that when we compared the discharge, hydrograph, and flow duration curves of the Pigeon River to Mill Creek, these expectations held true. The Pigeon River had a higher baseflow discharge (Table 1 and Figure 2) than Mill Creek even though its drainage area is smaller (Table 1). We can attribute a higher baseflow to forested land cover in the Pigeon River watershed (Figure 1). Even though Mill Creek has a larger drainage area (Table 1) it has a lower baseflow discharge than the Pigeon River (Table 1 and Figure 2) because it is driven by rainfall events that carry water over compacted fields and through tiles (Figure 1). Both the hydrograph and the flow duration curve illustrate the differences between peak and baseflow discharges in each watershed due to land cover. The hydrograph for Mill Creek shows a lower baseflow and higher peak flows than the Pigeon River (Figure 2). This difference can also be observed on the flow duration curve. The difference between the peak and the base is larger for Mill Creek than it is for the Pigeon River (Figure 3). These figures indicate that the Pigeon River is more stable due to constant baseflow and Mill Creek is flashier due to runoff.

The land use of a watershed also has a major impact on the concentrations of nutrients and ions we see in the stream. For the same reasons they stabilize discharge, forested watersheds decrease nutrient loading into streams from the landscape. Rainwater that falls on forested land infiltrates into the ground where any nutrients it may have picked up are deposited in the soil. When the water reaches the stream as baseflow, it is had rid itself of these nutrients. Rainwater that falls on agricultural or urban landscapes picks up nutrients from farm fields and lawns, and because it flows over the surface as runoff or is transported to the stream through storm sewers, it brings the nutrients with it to the stream. Nitrogen is found in lawn fertilizers and in fertilizers on agricultural fields so we would expect to see higher concentrations of nitrogen in Fleming Creek and Mill Creek and lower concentrations in the Maple River an the Pigeon River.

The highest concentration of nitrogen observed was in the Oden Fish Hatchery (Figure 4). This location is most likely highest because of the additional and unnatural inputs of nitrogen from fish feed and fish feces due to the hatchery. The Oden Fish Hatchery aside, we do see lower concentrations of nitrogen in the Maple River and the Pigeon River and higher concentrations in Fleming Creek and Mill Creek (Figure 4). The nitrogen is highest in Mill Creek because the land use in Mill Creek's watershed is predominately agriculture and therefore contributes large amounts of nitrogen from fertilizer in the form on non-point source pollution.

Alkalinity is the ability of the water to neutralize an acid. If water contains a high concentration of carbonates, it has a high alkalinity and therefore a strong capacity to buffer changes in pH. In Michigan, stream water accumulates carbonates if it receives groundwater that has picked up carbonates from limestone. Therefore we would expect to see high alkalinity in places that we determined received much of their flow from groundwater sources such as the Maple River and the Pigeon River. However, this is not the case. We observed higher alkalinity in Fleming Creek and Mill Creek (Figure 5). This could be due to differences in the underlying geology that was not part of our study.

The conductivity of water is an indicator of the amount of free ions in solution and therefore the waters ability to conduct an electrical current. If a stream has high conductivity, we may infer that it is fed by runoff that carries ions to the stream channel. We found that Fleming Creek and Mill Creek had the highest conductivities (Figure 6). This outcome is to be expected because the land use in these watersheds contributes to runoff more so than does the land use in our northern watersheds.

The surficial geology of a watershed has an effect on the discharge and consequently on the hydrograph of the main channel in the watershed. It also determines the size of substrate we see in the stream channel. The surficial geology for all but the Oden Fish Hatchery is shown in Figure 7. The proportion of outwash, medium to fine till, and lacustrine were calculated for each watershed. Outwash is composed of mostly permeable sand, till of a mix of sands and silts, and lacustrine is primarily made of fine silts and clays. The discharge of a stream with a high proportion of outwash in its watershed will most likely be high because rain water falling on the landscape will quickly infiltrate through the sand, contribute to the subsurface or groundwater flow, and enter the stream as baseflow. On the other hand, streams in watersheds with a high portion of lacustrine will have lower baseflows and higher peak flows because rain water cannot infiltrate clay well and as a result runs off the landscape. Discharge in watersheds of medium to fine till will be somewhere in the middle of these. The Pigeon River watershed is largely composed of outwash and Mill Creek of medium to fine till (Figure 7). As one can see from the hydrographs of these two streams in Figure 2 and the discharge measurements in Table 1, the Pigeon River has a higher discharge and more stable flow than does Mill Creek.

Channel substrate is determined by the surficial geology of the watershed as well. The median particle size (D50) found in a stream channel is dependent upon the composition of the watershed geology because the stream channel forms by down cutting through this material. Streams in watersheds dominated by outwash will have a larger median particle size than streams in watersheds dominated by lacustrine because sand is larger in diameter than clay. We found that the outwash watersheds (the Maple River and the Pigeon River) had higher median particle sizes than the watersheds dominated by till and lacustrine (Fleming Creek and Mill Creek) (Table 2).

The stream discharge, stream channel, and water quality, determined by the land use and surficial geology of the watershed, influence the types and abundances of macroinvertebrates and fishes able to live in a particular stream. The level of pollution in a stream impacts the species of macroinvertebrates able to survive there. Streams that carry high constant loads of pollutants will be home to macroinvertebrates that have a high pollution tolerance. We expect the overall pollution to be low in forest watersheds that filter pollutants and high in urban and agricultural watersheds that do not. By looking at a measurement called the Hilsenhoff Biotic Index (HBI) we can determine which streams have pollution tolerant species. We found the Oden Fish Hatchery and Mill Creek to have the highest HBI's (6.78 and 6.66 respectively) (Table 3). An HBI between 6.51 and 7.25 indicates poor water quality with very substantial organic pollution likely. The HBI for Fleming Creek indicated good water quality with some organic pollution probable. An HBI below 3.75 is a sign of excellent water quality where organic pollution is unlikely. Both the Maple River and the Pigeon River were in this category (Table 3). The effect of water quality on macroinvertebrates can also be observed by counting the number of individuals in the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). A high number of individuals in each of these orders yields a high EPT richness, a high percentage of EPT out of the total number collected, and indicates good water quality. The Pigeon River and the Maple River both had high EPT richness values and high percentages of EPT over the total (Table 3). Mill Creek had both the lowest EPT richness and percent EPT over total collected (Table 3). Once again, this is an indication of higher water quality in our forested northern watersheds and lower water quality in our agricultural and urban watersheds.

The species of fish and diversity of species within a particular stream reach can also identify pollution problems within a system. An index called the Shannon-Wiener Index is an indicator of water quality based on fish species found. A high Shannon-Wiener Index (between 3 and 5) suggests clean water while an Index less than one suggests polluted water. Another value, called Simpson's D, is an indicator of fish diversity. A value close to 1 suggests little diversity and as the value approaches zero, a higher diversity is present. We would expect pollution intolerant species and a high diversity of species to be found in our northern watersheds that have cleaner water and constant baseflow. We found this to be true. The Pigeon River and the Maple River had the highest Shannon-Wiener Indices and had Simpson's D values closest to zero (Table 4). Mill Creek had the highest number of pollution tolerant species and a Simpson's D value closest to one (Table 4).

The way a stream responds to wet and dry weather events, the quality of its water, and the substrate the stream bed is composed of are all dependent upon the proportions of various land uses in the watershed and on the surficial geology of the watershed. These physical and chemical features of the stream influence what types of biology, such as macroinvertebrates and fish, are able to live there. It is important to analyze the relationships between these components and observe how they interact in order to get a full understanding of the processes occurring in fluvial ecosystems.

## APPENDIX

### Figures:

Figure 1. Land use in the watersheds of five sites studied in 2006.

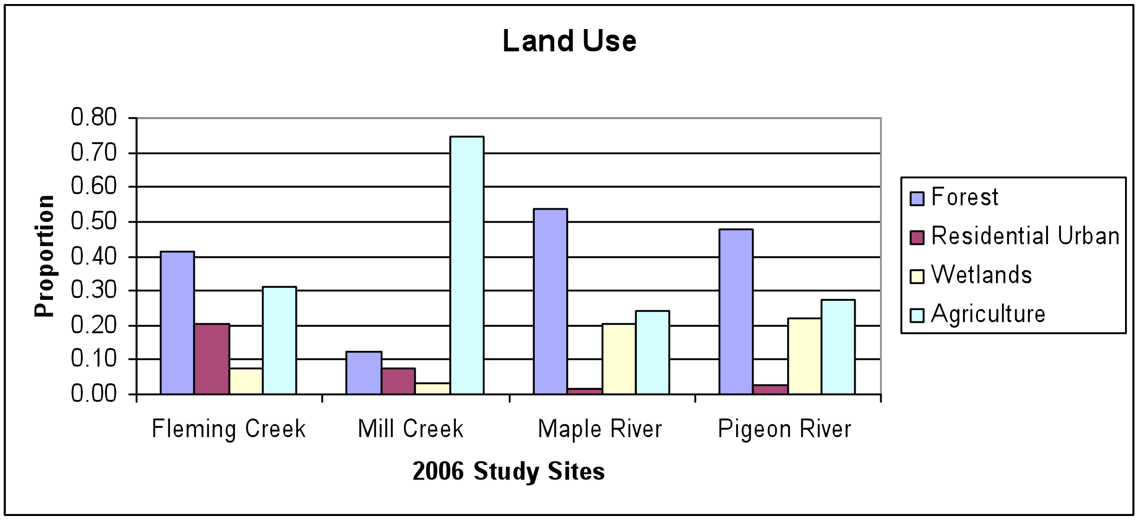



Figure 2. Hydrograph for two sites studied in 2006.

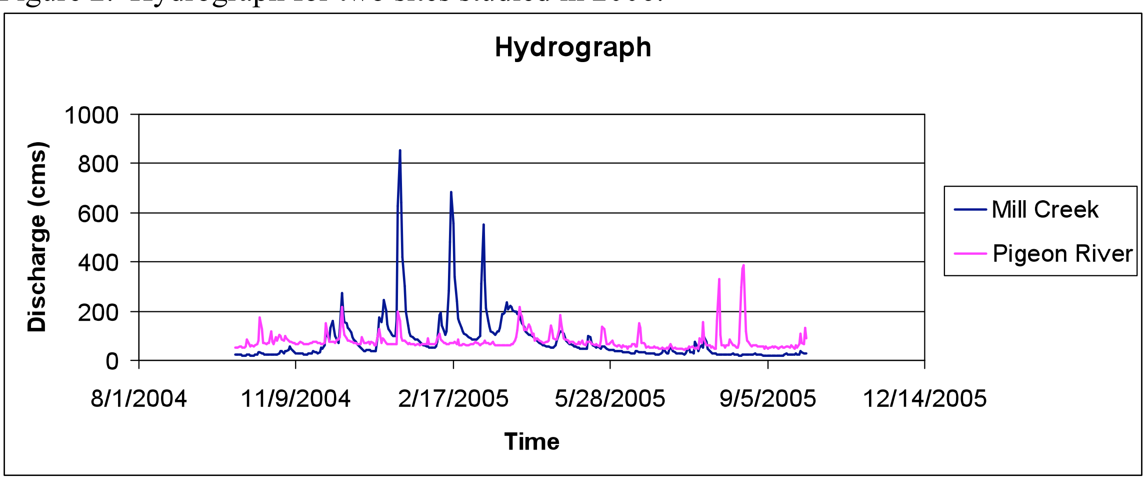


Figure 3. Flow Duration Curve for two sites studied in 2006.

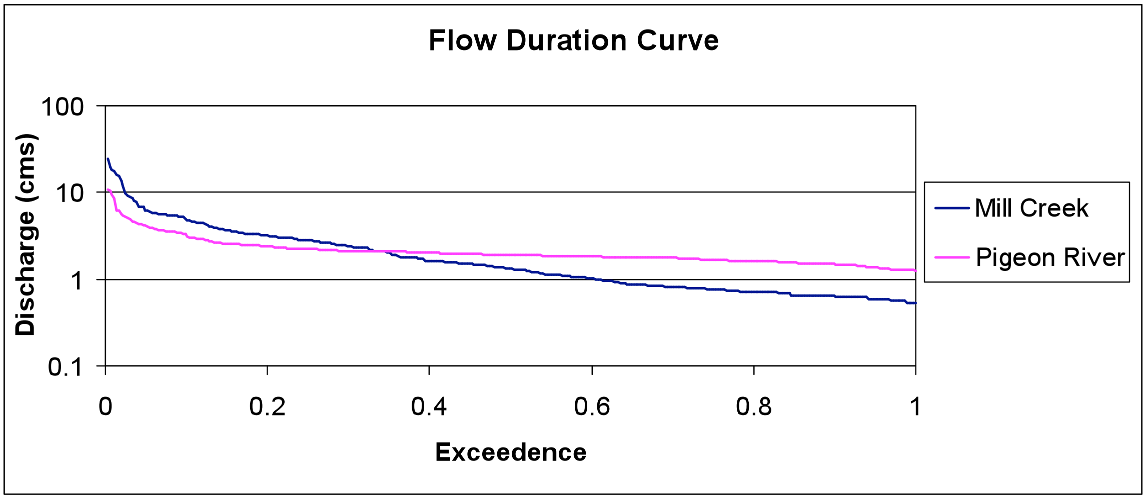



Figure 4. Nutrient Concentrations for Nitrate (NOx-N) for five sites studied in 2006.

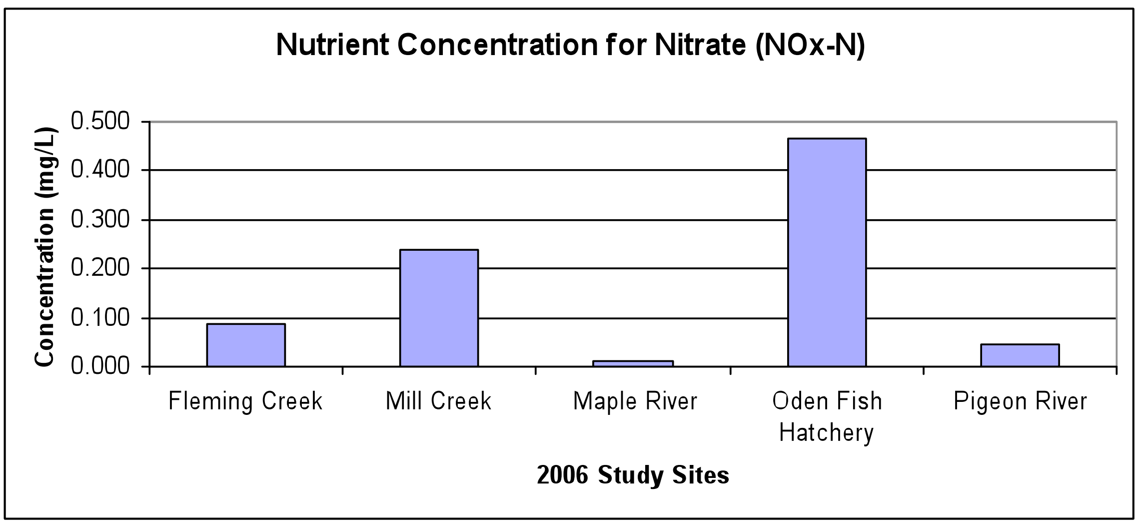


Figure 5. Alkalinity Measurements for five sites studied in 2006.

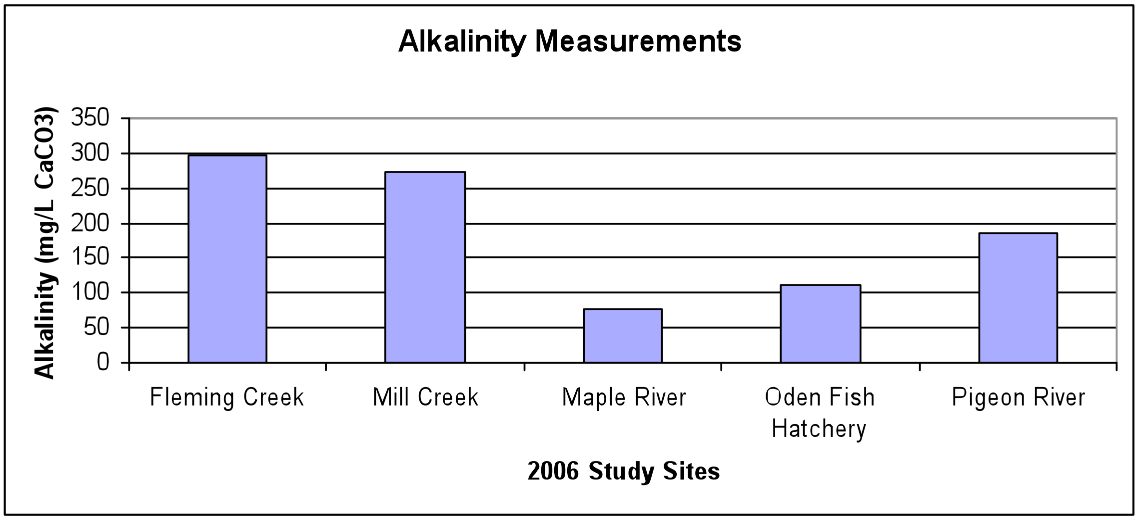



Figure 6. Conductivity measurements for five sites studied in 2006.

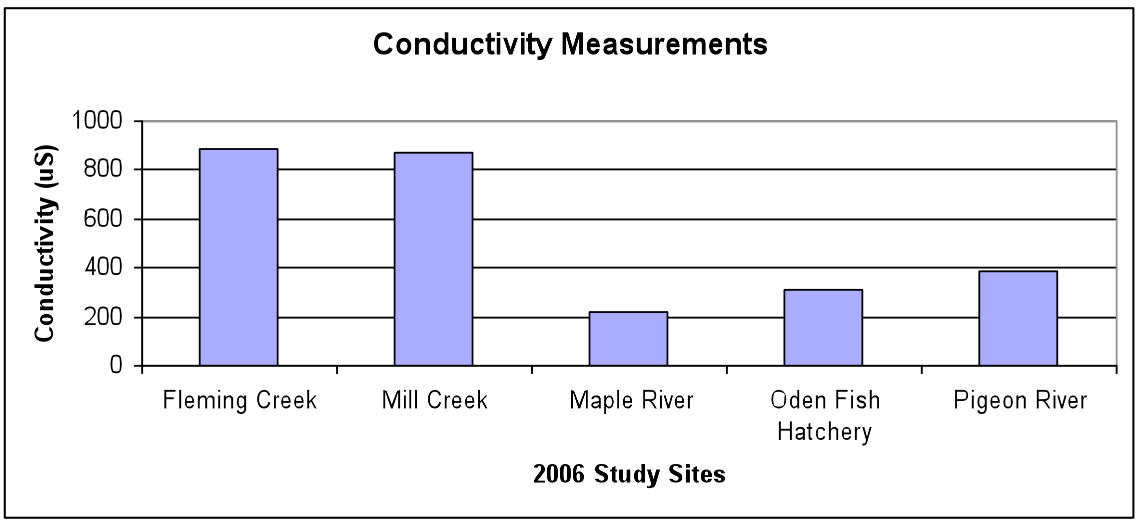
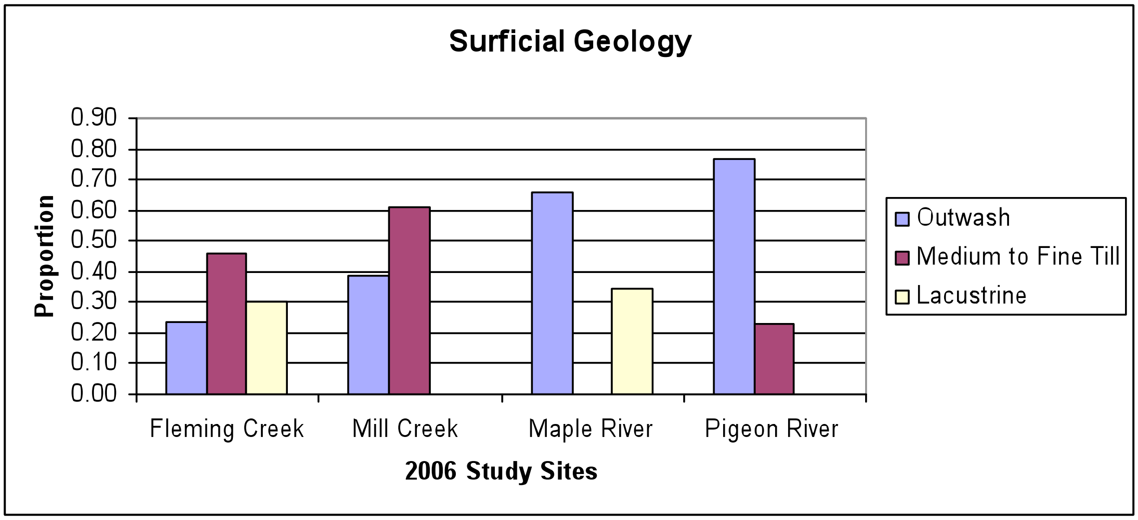


Figure 7. Surficial geology in the watersheds of five sites studied in 2006.




**Tables:**

Table 1. Drainage area and discharge measurements for five sites studied in 2006.

| | Fleming Creek Average | Mill Creek | Maple River | Oden Fish Hatchery | Pigeon River |
|---|---|---|---|---|---|
| Drainage Area ($km^2$) | 50 | 206 | 503 | - | 143 |
| Discharge (cms) | 0.95 | 0.73 | 3.11 | 0.15 | 3.41 |

Table 2. Reach substrate size for five sites studied in 2006.

| | Fleming Creek | Mill Creek | Maple River | Oden Fish Hatchery | Pigeon River |
|---|---|---|---|---|---|
| Substrate – D50 (mm) | 11 | 0.062 | 18 | 14 | 28 |

Table 3. Pollution and order diversity indices for macroinvertebrates in five sites studied in 2006.

| | Fleming Creek | Mill Creek | Maple River | Oden Fish Hatchery | Pigeon River |
|---|---|---|---|---|---|
| HBI | 4.93 | 6.66 | 3.58 | 6.78 | 3.07 |
| EPT Richness | 4 | 3 | 9 | 4 | 9 |
| %EPT/Total | 88.3 | 18.0 | 86.0 | 20.0 | 75.0 |

Table 4. Pollution and diversity indices for fish species in four sites studied in 2004.

| | Fleming Creek | Mill Creek | Maple River | Pigeon River |
|---|---|---|---|---|
| Shannon-Wiener Index | 1.63 | 0.59 | 1.91 | 2.09 |
| Simpson's D Value | 0.21 | 0.74 | 0.18 | 0.14 |