SUNY New Paltz and DEP sponsored NSF REU Summer 2010 Project Description

Faculty mentor Dr. John Rayburn:

Surficial mapping of the upper Esopus drainage network

Suspended sediment-sourced turbidity is the number one water quality impairment watershed management issue in the upper Esopus Creek watershed. Esopus Creek is the primary feeder stream for the Ashokan Reservoir part of the NYC water supply. A primary source of the suspended sediment is from fluvial and mass-wasting erosion of glacial till and pro-glacial lacustrine silts and clays. The heterogeneous distribution of the source material is poorly characterized at this time. Although the New York State surficial geological map does not show it, there are several outcrops of glacial lacustrine silts and clays exposed in many of the tributary stream corridors. In conjunction with the NYS Geological Survey we aim to construct a higher resolution map of the surficial sediments to identify and characterize the potential sediment sources, and to help DEP modelers better predict sediment entrainment and transport through the system.

Monumenting and surveying stream banks to monitor stability

There are several "cutbanks" in the upper Esopus Creek watershed stream network that are currently eroding at variable rates and contributing variable sediment loads. NYCDEP and Ulster County Soil and Water Conservation District are working to establish a streambank erosion hazard monitoring program using the BANCS model approach developed by Dave Rosgen (Rosgen, 2006). The monitoring results will be used to record the variability of erosion and potential loading as well as provide input data for sediment loading numerical modeling. We will utilize the BANCS method (topographic survey, bank composition characterization, bank pins) to predict annual streambank erosion rates for several locations in the watershed.

Modeling of particulate transport through monitored stream reaches

NYCDEP is working on computer models of stream discharge and sediment transport through the upper Esopus system. New field data (bank erosioin rates and possible sediment loading) will be used to help validate the model, and suggest possible refinements.

Conducting wetland and aquatic inventories

The NYC DEP has been conducting wetland and fish assemblage inventories in the upper Esopus. Wetlands may act as buffers against the throughput of fine particulates, and fish populations may be sensitive indicators to changes in the physical system. Students will get a chance to assist with both of these important inventories.

<u>Faculty Mentor Dr. David Richardson:</u>

<u>Large woody debris in Stony Clove watershed</u>

Large woody debris (LWD) and debris dams can modify the physical habitat, chemistry, and biology of stream ecosystems. LWD and debris dams can change the shape of stream channels, alter water velocity and stream bed erosion patterns, and increase hydrologic retention through the creation of pools and eddies. LWD and debris can create habitat for stream organisms, increase deposition and retention of nutrients and organic matter (dissolved and particulate) modifying stream chemistry and biology. The students working on this project will spend time in the field mapping (GPS) and tagging LWD and debris dams throughout the Stony Clove and Esopus watersheds. Depending on the students' interest, the project could involve GIS mapping of LWD patterns or analyzing movement of LWD and debris dams following storm events. The students could also characterize the geomorphology and hydrology of stream reaches with and without LWD and debris dams using tracer studies and modeling techniques.

<u>Didymo geminata (rock snot) in Esopus Creek</u>

Abundance of the nuisance stream alga Didymosphenia geminata has unexpectedly increased in streams and rivers worldwide in recent decades. D. geminata (Didymo) is informally called "rock snot" because during blooms (i.e., periods of rapid growth), the diatoms produce long stalks which forms a mat on the stream bottom and resembles mucus. Didymo is capable of modifying the physical habitat and biology of the streams due to the large amount of growth on the stream bottom. In New Zealand, Didymo blooms, likely spread by recreational fishermen, have caused recreational and economic damages (>$50 million). The Esopus Creek is one of five known bloom locations in New York State. The students working on this project will work closely with the local United States Geological Survey (USGS) group to investigate the ecology of Didymo, including the chemical and hydrological causes of Didymo blooms in the Esopus Creek using microscopy and water chemistry techniques. In addition to field measurements, the students could also plan and carry out experiments to look at chemical causes of Didymo growth.

<u>Metabolism in Esopus Creek watershed</u>

Measurements of metabolism, such as photosynthesis and respiration, in aquatic ecosystems are valuable integrators of ecosystem function in freshwater habitats. These measurements can indicate how aquatic ecosystems function as a by-product of organic matter inputs (e.g. leaves, waste water), land use (e.g. forests, agriculture, residential), geographic location, food web structure, and other ecosystem characteristics. Consequently, ecosystem metabolism is routinely measured in aquatic systems ranging from small urban streams to Artic lakes using dissolved oxygen sensors and meteorological stations. Currently, there are several sensors installed in Esopus Creek and within the downstream reservoir. Students will use current data to calculate metabolism within the Esopus Creek and reservoir. Further, students working on this project can also deploy dissolved oxygen sensors throughout the Stony Clove streams to make metabolism measurements in streams and make comparison among streams, to the Esopus Creek, and to the downstream Ashokan Reservoir.

Faculty Mentor Dr. Megan Ferguson:

Impact of Stony Clove Creek Watershed on Disinfection Byproduct Formation

Stony Clove Creek, a source of water to Ashokan Reservoir and ultimately New York City, is known to have high sediment loads, and substantial levels of dissolved organic matter may co-occur with that sediment. Since New York City does not filter its drinking water, this imparts a risk of generating disinfection byproducts – harmful halogenated compounds that form when source water that contains dissolved organic matter is treated with chlorine prior to distribution. To examine the extent of this problem, students will collect water samples in various locations throughout the Stony Clove watershed and downstream toward Ashokan Reservoir. Basic water quality parameters will be collected onsite, and more in-depth information such as ion concentrations, total organic matter, and humic acid fraction will be determined in the lab. Water samples will subsequently be chlorinated in a fashion similar to New York City's drinking water treatment, and students will identify and quantify disinfection byproducts using UV-visible spectroscopy, gas chromatography-mass spectrometry (GC-MS), and other analytical techniques.

Depending on student interest, samples collected in the same location during storm events can be compared to those collected during non-storm events to determine how transport of organic matter and disinfection byproduct formation is affected.

Faculty Mentor Dr. Lawrence McGlinn:

Modeling Stony Clove, Upper Esopus Basin, New York (GIS based)

This project will concentrate on the compilation and analysis of data for Stony Clove, a small sub-basin in the Upper Esopus Creek watershed in the Catskill Mountains, NY. Overlaying a range of existing data in our GIS (aerial photography, LIDAR data, DEMs, soils data, hydrologic and geologic data), we will create a three-dimensional model of the Stony Clove basin. This model will aid in analyzing the geomorphology of Stony Clove. To this base model we will add data gathered in the field, creating visualizations of bio- and geo-chemical processes in the waters of the clove. In subsequent years, we will build a robust environmental database on this foundation. Ultimately, our model will represent in detail the reality of Stony Clove as an outdoor laboratory.

NSF REU Summer 2010 Project (DEP Modeling Group)

Data and Modeling of Snowpack and Snowmelt in West-of-Hudson Watersheds

The timing and magnitude of the development and melting of the snowpack in the West-of-Hudson (WOH) watersheds is critical to the seasonal patterns of reservoir storage; the potential amount of spill from the reservoirs; timing of large inflows controlling turbidity inputs to the reservoirs; and timing and levels of nutrient loads and reservoir residence time controlling eutrophication. Prediction of snowpack for WOH watersheds is made more difficult due to the terrain in the watershed, where elevation, slope exposure and temperature have some control on the rate of snowpack development and melt. DEP has collected snowpack data for many years with bi-weekly surveys. An important link is to tie these survey values to the timing and magnitudes of flows entering the reservoirs. This project involves a review of DEP snowpack data, along with other meteorological data to better understand spatial and temporal variability of the snowpack and to better quantify watershed snow water equivalents on the reservoir watershed scale. Tools for use in this investigation could include GIS to better understand the factors important to the spatial variability of snowpack and the use of models to predict snow melt and connect snowpack data estimates to reservoir inflows.

Evaluation of different methods for estimating evapotranspiration (ET)

Evapotranspiration, including evaporation from soils and water bodies and transpiration from vegetation, are important components of the hydrologic cycle. NYC DEP is undertaking a long term project to study the possible effects of future climate change on the NYC water supply. Since there are no observed data for the future, Global Circulation Model (GCMs) projected climate is used in association with a suit of models that together help simulate future water quantity and quality for the regions contributing water to the NYC water system. Algorithms for calculating evaporation/evapotranspiration are important components of these models. Some algorithms require a large number of input variables, while more simplified approaches are available that make use of a more modest number of variables.

The purpose of this project it to:

- Evaluate estimates of present day evaportranspiration made using data collected from the DEP meteorological station network.
- Make similar evaluation for a future time period using meteorological data for future climate conditions. These downscaled data will be available from DEP.

- Compare the relative differences in evapotranspiration estimated by different algorithms under present and future climate conditions.

This work would help in evaluating the accuracy of the data simulated by the different models currently used as part of the climate change study in progress at NYC DEP.

Establishing a relationship between turbidity and total suspended solids (TSS)

Turbidity is often used as a surrogate for total suspended solids (TSS) in situations where TSS measurements are labor intensive or impractical. Watershed scale water quality models such as the soil and water assessment tool (SWAT) provides sediment output in the form of TSS (mg/L). Therefore it is important to establish a relationship between turbidity and TSS for better interpretation of model output for sediment calibration. Turbidity being an optical property is affected by factors such as color of dissolved solids, temperature, and size and shape of mineral particles. It may be also important to determine if there are trends in turbidity vs. TSS relationship resulting form variations in the relative proportions of stream sediment sources, and as levels of stream turbulence influences the particle size distribution of the TSS.

Objectives:

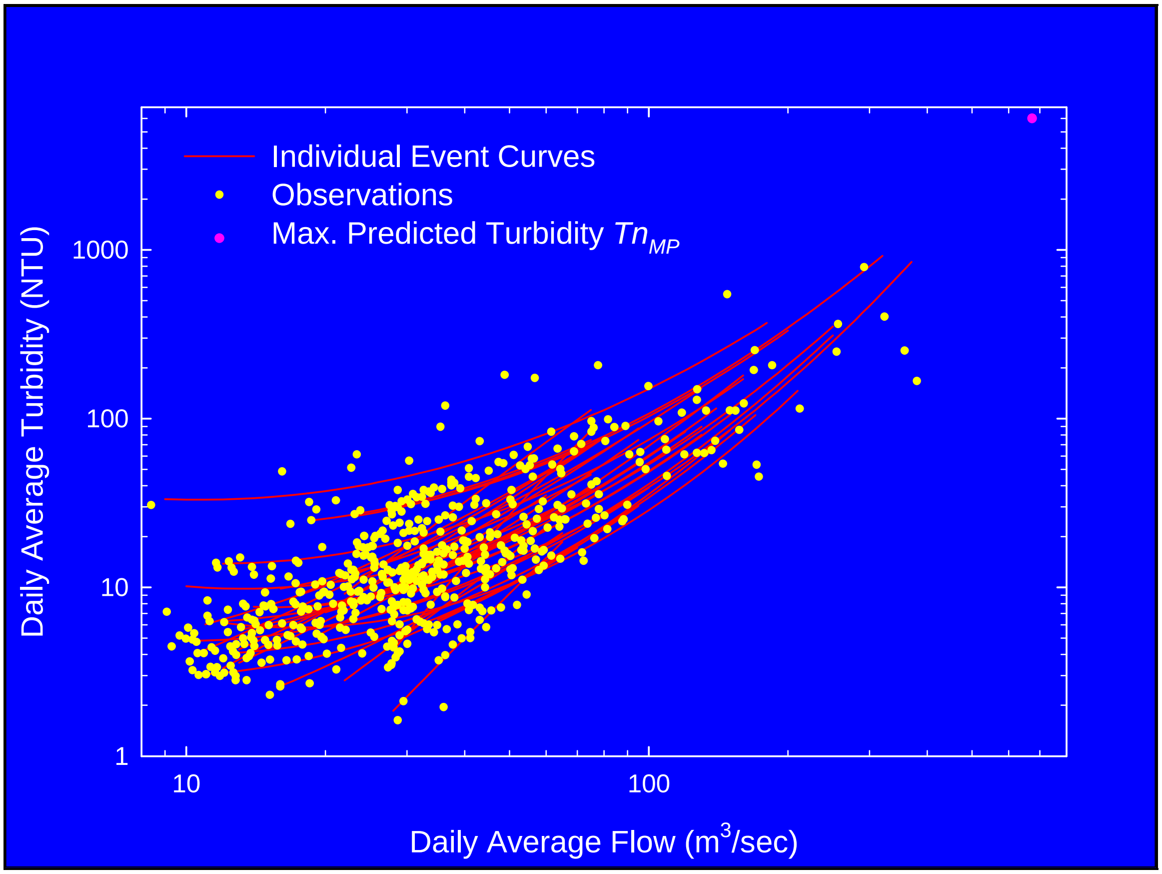
- To evaluate whether turbidity could be used for a satisfactory estimate of TSS
- To determine the significance in observed turbidity vs TSS relationship due to seasonality, flow regimes, and location

Data:

Available turbidity and TSS data from DEP watersheds

Evaluation of turbidity vs flow relationships in Esopus Creek

Esopus Creek turbidity is automatically monitored near the inlet to the Ashokan reservoir close to the USGS gauge at Coldbrook. Turbidity and stream discharge are measured concurrently at a 15 min interval, and such data have been collected for over a five year period. Examples of how these data have been used to develop predictive relationships between stream discharge and turbidity are shown below.



Flow weighted mean daily turbidity vs. mean daily stream discharge at Esopus Creek site E16. A global predictive relationship based on all points is used in most modeling applications. The red lines show the best fit relationship for individual storm events. From a presentation by the Upstate Freshwater Institute

Such relationships make a fundamental limitation of turbidity/TSS model development apparent: While there is clearly a positive relationship between increases in stream discharge and increases in stream turbidity levels, the relationship is highly non-linear, and also highly uncertain as evidenced by a large degree of scatter (high residuals) between predicted and measured turbidity. Changes in the data set used to develop the relationship or in the methodology used to fit a predictive equation to the data can lead to large variations in estimated turbidity loads to the reservoirs, which can in turn lead to uncertainty in predictions of reservoir turbidity levels. Preliminary examination of the uncertainty in the turbidity vs discharge relationship have found that the uncertainty is much less for the individual storms than for the entire data set (figure above). This suggests it is processes impacting the overall response of the system to storm event conditions that are largely responsible for the variations in the turbidity discharge relationship.

The goal of this project would be to examine inter-storm variations in the turbidity vs flow relationship using data collected at Cold brook. The student will test if predictions of stream turbidity could be improved: 1) if the turbidity levels at the onset of a storm event are known; or if 2) other measures of watershed conditions such as time of the year, spatial pattern of precipitation, and antecedent dry conditions at the onset of the storm are included in predictive equations (models) of stream turbidity .