ASSESSING NUTRIENT RUNOFF IN THE LITTLE CHAZY RIVER, NORTHEASTERN NEW YORK: A SYNOPTIC WATER SAMPLING STRATEGY IN NESTED SUBWATERSHEDS

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Lake Champlain, in northeastern New York and Vermont, is an oligotrophic to mesotrophic water body with low to moderate levels of phosphorus and nitrogen, the primary nutrients for primary productivity and principal determinants for associated water quality issues. Major sources of nutrients in Lake Champlain include point sources such as municipal sewage treatment plants in the cities of Plattsburgh and Burlington, and non-point sources including agricultural inputs. Extensive dairy operations in the Lake Champlain basin produce large quantities of manure, which is applied back to soils and can potentially become a major source of nutrients to nearby surface waters. Agricultural best management practices, including winter storage of manure in holding lagoons, have been applied extensively over the last twenty years. In spite of these efforts, water quality concerns persist at the mouths of some tributaries (New York State Department of Environmental Conservation, pers. comm., 2009). In this study we examine nutrient runoff to Lake Champlain from the Little Chazy River and its relationship to the hydrogeology, land cover and land-use practices in the watershed.

The Little Chazy River watershed (basin area = 145 km^2) is typical of rural, medium-sized watersheds in the region, demonstrating a broad range of watershed issues and concerns reflected throughout the Champlain lowland. The Little Chazy River originates in upland forests in the northeastern foothills of the Adirondack Mountains and flows eastward through the Champlain lowland to its mouth at Lake Champlain. It has two principal tributaries, Farrell Brook (basin area = 24 km^2) and Tracy Brook (basin area = 25 km^2). The headwater region is a predominantly forested area of moderate relief (<400m) that is underlain by thin glacial soils (generally <3m thick), Cambrian clastic sedimentary rocks and high-grade Mesoproterozoic metamorphic rocks. This region includes a large area of exposed sandstone bedrock, or sandstone pavement, known locally as Altona Flat Rock. Mainstream gradient in the headwater region commonly exceeds 10 m/km. The river descends steeply through the dense headwater woodlands to the Champlain lowland and flows through a patchwork of forested and agricultural lands before emptying into Lake Champlain. The Champlain lowland is underlain by thick glacial, glacial-lacustrine, and glacial-marine sediments, and lower Paleozoic sedimentary rocks. Local relief in the lowland is generally less than 100 m and the mainstream channel gradient averages approximately 1 m/km.

Methods

SUNY Plattsburgh and Miner Institute (SUNY/Miner) currently operate and maintain stream-gaging stations at as many as 17 locations in the Little Chazy River watershed (Fig. 1). The stations operate during ice-free periods only and records vary in length or continuity depending upon data needs and

In: Cockburn, J.M.H. and Garver, J.I., Proceedings from the 2009 Mohawk Watershed Symposium, Union College, Schenectady NY, 27 March 2009

available resources. Records for the U.S. Geological Survey (USGS) gaging station near the river mouth east of Chazy were obtained from the USGS, Water Resources Division office in Troy, New York. All SUNY/Miner stations are equipped with Tru-Trac WT-HR water height (stage) dataloggers. Rating curves for each station are calibrated using the midsection method for determining discharge (USGS, 1977). Stream discharge was used to estimate nutrient loads from different portions of the watershed.

We adopted a high-resolution synoptic water-sampling strategy to determine the spatial and downstream distribution of nutrient concentrations in streams within the Little Chazy River watershed (Fig. 1). Synoptic sampling involves the collection of closely spaced water samples in a short time period (generally less than four hours) to provide a snapshot of nutrient concentrations and loadings throughout the watershed. Sample spacing along the mainstream, tributaries and other inflows varied with accessibility and land use. Channel distance between samples varies from more than 5 km in forested upland regions to a few hundred meters in villages or agricultural lands where anthropogenic inputs such as ditches and drains are more common. We collected 12 synoptic sample suites at approximately four-week intervals in 2008 from approximately 64 sites on the mainstream, tributaries and agricultural ditches and tile drains. The sample suites were broadly distributed across three discharge ranges: Q = < $1 m^3$/sec (n=4), 1.0 – 10 m^3/sec (n = 7) and greater than 10 m^3/sec (n=1).

Water samples were collected in acid-washed 500 ml polyethylene bottles within a period of 4 hours to minimize temporal variations in nutrient concentrations. Samples were transported in coolers back to the lab and immediately split into two fractions; one which was filtered through a 0.47 mm membrane filter to remove particulates and the other left unfiltered. Filtered subsamples were analyzed for nitrate using a Dionex Ion Chromatograph with conductimetric detection and for soluble-reactive phosphorus (primarily phosphate) colorimetrically using a UV-Vis spectrophotometer with the ascorbic acid method (APHA, 1998). Unfiltered subsamples for Total Kjeldahl nitrogen were digested on a block digester using sulfuric acid with a copper sulfate catalyst (APHA, 1998), followed by analysis for ammonium using the salicylate-nitroprusside-hypochlorite procedure on a flow injection analyzer (APHA, 1998) modified for a Bran-Luebbe (Technicon) autoanalyzer. For total phosphorus, unfiltered water samples are digested using potassium persulfate in sulfuric acid on a block digester (APHA, 1998), followed by analysis for soluble-reactive phosphorus.

Results and Discussion

Stream discharge in the Little Chazy River is spatially heterogeneous and seasonally variable. Effluent conditions predominate in the upper and middle portions of the watershed, except for a local influent reach at the site of a former hydroelectric dam on Altona Flat Rock. The greatest proportion of stream flow during baseflow conditions is generated where the river descends from the uplands at Altona Flat Rock to the Champlain lowland near the village of West Chazy. Much of the increase can be attributed to several high-discharge springs that occur in this part of the watershed. The Little Chazy River becomes influent again as it crosses the Champlain Lowland. The influent reach occurs in an area of complex geological structure. The effect of water loss in this reach is most pronounced during low-magnitude baseflows and its size varies with baseflow magnitude. At low flow, nearly all of the stream flow is generated in the upper reaches of the watershed. As stream flow increases following runoff events, a greater proportion of baseflow is generated in lowland agricultural regions.

Nitrate concentrations in headwater forests were typically low (< 1 mg/L NO_3^-), and increased substantially upon entering lowland agricultural regions. Occasional abrupt increases in nitrate concentrations within the agricultural areas may be attributed to high concentrations in agricultural ditches or tiles, but this trend was not consistent due to the low discharges measured in many of these tributaries. Nitrate concentrations generally leveled off at 2-3 mg/L in the agricultural area between West Chazy and Chazy and actually decreased in a small, narrow impoundment immediately upstream from the village of Chazy. Nitrate decrease in the impoundment is most likely due to sequestration in algae, aquatic macrophytes and sediments, particularly during the growing season. Nutrient concentrations increased substantially in the 7 km-long reach between the village of Chazy and Lake Champlain, where the river traverses a low-relief, intensively managed agricultural area developed on deep glacial-marine soils. Nitrate concentrations increased markedly during high-magnitude runoff events and retention in the Chazy impoundment decreased as flushing occurred. Consequently, the downstream increase in nitrate concentrations was more uniform during events.

Downstream changes in phosphorus (total phosphorus and soluble-reactive phosphorus) concentrations generally mirror those observed in nitrate concentrations but exhibited substantially more variability, possibly due to measurement errors associated with relatively low phosphorus concentrations (10-100 mg/L).

The highest nutrient loads occurred during high-magnitude storm runoff events due to moderately elevated concentrations combined with high discharge. During these periods, bank-full and over-bank conditions in some reaches and overland stormflow probably contributed to contamination of surface waters due to erosion of surface applied manure in flood plains. During low-flow conditions, tile-drain systems provide much of the agricultural loading and macropore flow may exacerbate nutrient loss to surface waters.

Acknowledgements

We gratefully acknowledge the contributions from all of the many students who participated in research in the Little Chazy River watershed over the past two decades, especially Ethan Sullivan, Brian Huber, Derek Smith, Sean Keenan and Kevin Kieper, who were directly involved in the current study. Special thanks to the Office of Sponsored Programs and the Lake Champlain Research Institute at SUNY Plattsburgh. This study was funded by the New York State Department of Environmental Conservation and The Nature Conservancy.

Reference

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Association. Clesceri, L.S. A.E. Greenberg and A.D. Eaton, Eds.