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Evaluating Septic System Inputs into Sodus Bay using Oblique Imagery, Optical Brighteners, and DNA-based tracers.

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Keywords

- Septic fields
- Non point source pollution
- Optical Brighteners

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Introduction

Sodus Bay is an important Bay in Lake Ontario that has been heavily impacted by nonpoint source pollution. The Bay is considered to be a Class B stressed, priority waterbody according to the NYSDEC. Pollution in it has resulted in eutrophication, algal blooms, and excessive weeds in parts of the watershed (1). These issues have led to several studies which have determined that nutrient contributions from developed parts of the watershed are the source of these water quality issues. Nonpoint source pollution from septic fields are an important contributor of nitrogen and phosphorous to groundwater, shorelines, streams, and lakes (2). It has also been implicated in bays and water bodies associated with Lake Ontario (3). Addressing it with watershed policy has been difficult for two reasons: 1) identifying where leach fields are hydrologically connected to water bodies is difficult to do, and 2) determining the magnitude and residence time of septic field pollutant fluxes within watersheds is difficult. Our lack of knowledge in this issue of hydrologic connectivity greatly restricts the kind of management practices and policies we can employ to prevent nonpoint source pollution from septic systems.

In a completed study of septic field distributions in Oak Orchard Watershed (6), we have been able to successfully identify septic fields 70 to 75% of the time using Pictometry Oblique Imagery. Canopy cover was the main problem of the technique, preventing the identification of 10% of the septic systems. Certain kinds of septic systems (e.g. cess pools) were also not mappable. Fortunately, these are older systems that are seldom used and are not very common. Imagery taken in the early spring had the best results because the color differential of grass growing on septic fields was enhanced relative to grass that hadn't started growing from lack spring nutrients and moisture. This work demonstrated that this technique can be used to map septic fields and potentially, septic systems with leaks (Figure 1, below). In the proposed study, we will use the spatial information provided by this technique to rank stream and shoreline segments in their susceptibility to septic inputs, and test this using direct water quality sampling of the stream and bay.

The project has the following objectives:

1) *Map all septic leach fields in Sodus Bay watershed (Figure 3) using Oblique Imagery.*

2) *Rank stream reaches in the watershed by their proximity to septic fields using DEM derived flowpaths and spatial statistics such as septic field density.*

3) *Physically measure water quality (including the presence or absence of optical brighteners) in the stream reaches to determine if septic leach fields are having a measurable impact water quality.*

Results & Discussion

Four hundred and fifty one septic fields were mapped in the watershed from the Pictometry imagery. Two rounds of low flow samples were collected in August (August 8 and 9), and September (Sept 9-11). Twenty eight sites representing first, second and third order streams were visited, but of those only 16 had any water present. Table1 located in the adjoining appendix presents details on the site locations, stream order, and septic field metrics (total number in the contributing area, contributing area, septic field density). Table 2 in the Appendix presents the waterquality data collected.

Based on the waterquality data collected, sites 6, 10, and 17 are the stream segments most impacted by nutrients. Two of these sites had low initial OB concentrations, however their fluorescence ratio suggest that Opitical Brighteners were present. Scatter plots revealed no obvious relationships between septic field density with either Nitrate concentration or phosphate concentration. A regressional relationship between Optical Brightener initial concentration and septic field density suggests there is a weak relationship between these two factors (Rsq=29%). The slope has a P-value of 0.17 which means that 83% of the time the slope of the relationship will be an accurate predictor of OB concentration.

In summary the results of the analysis are inconclusive so far. Work will continue with the datasets provided by this project this summer to better evaluate the relationship between septic field metrics and stream chemistry.

This report was prepared for the New York State Water Resources Institute (WRI) and was made possible through funding authorized under Section 104b of the Water Resources Research Act, administered by the US Geological Survey

Policy Implications

This project has provided some valuable data that will be useful for watershed planners and policy makers. First, by identifying the number of septic systems in subbasins with greater precision, modeling of the septic contribution of nitrogen and phosphorus to watershed, lake and aquifer nutrient budgets will be more accurate. This will make the TMDL, coastal and lake assessments of septic pollution more defendable, because it will be based on actual data rather than inferences from demographics. Spatial units of census blocks and tracts are not as useful as precise locations of septic fields. This information is essential if we want to implement spatially-distributed models for predicting septic field inputs. Third, parts of the watershed or shoreline, where soil and groundwater table characteristics tend to cause septic systems to breakdown or short-circuit, can be identified. This information will allow watershed managers to direct policy changes towards problem areas, rather than to all septic systems. Fourth, by identifying the location of improperly working septic field systems, policy can be directed toward fixing individual septic systems rather than restricting the use of septic fields in general. This can increase the number of options that watershed managers have in areas that historically utilized septic fields. Targeting individual septic systems may be more cost effective and easier to implement politically. In some areas, homeowners are being compelled to link to public sewer systems, even if their septic systems are working properly. Obviously a cost-benefit / environmental-benefit analysis needs to be conducted to determine whether septic systems or public sewer systems are better for an area. The information gleaned by this research will make this kind of analysis possible, when currently it is not.

Methods

Septic field mapping

Oblique Imagery was accessed through Pictometry-Connect (pol.pictometry.com). This provided us with access to Oblique Imagery in the study area for the following years: 2013, 2010, 2008, 2006, 2004, and 2002. Each year of imagery contains four oblique (40 degrees from the nadir) views oriented along the four cardinal directions (N, S, E, W). A top down view is also available in some year's of imagery. Septic fields were identified from the imagery and digitized as points in the POL interface. Septic fields were digitized, township by township, and then downloaded as KML files. The KML files were then converted to shapefiles in ArcGIS. After some early experimentation, the following approach proved to be the most efficient way to map the septic fields in the imagery. The most recent year of imagery was evaluated first and the imagery was viewed along each of the four directions to look for evidence for leach fields. The evidence looked for included: parallel lines where the grass was either darker of lighter than the surrounding grassland, dark areas approximately rectangular in space, or faint rectangles where one or more corners were dark. Care was taken to exclude management features that could be mistaken for leach fields such as old garden areas, and the parallel tracks from lawn mowing. The imagery was evaluated for three more subsequent years if nothing was found in the first year. Based on trial and error it was discovered that in most situations if a leach field was not identified by the third year of data analysis, the feature is not present in any of the data.

Optical Brighteners

Optical Brighteners are minor additives of laundry detergents. Although their primary use is to enhance the colors of clothes, they will fluoresce if exposed to ultraviolet light. Because they don't breakdown in septic systems, they have been used as evidence for the presence of septic leachate if they are detected in streams. The most currently methodology (Cao etal, 2009) evaluates them by exposing a sample to UV light, and then measuring the quantity of OB with a standard after a period of 0, 5 and 10 minutes. Traditionally, the measurements at 5 and 10 minutes are only carried out if the initial OB measurement is greater than 5ug/l. This methodology was developed to combat false positives, which occur frequently because colored dissolved organic matter often fluoresces from being exposed to UV light. The methodology works because OB fluorescence rapidly decays with time, whereas natural occurring fluorescence does not. Our

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initial run of samples didn't reveal any OB greater than 5 except for a few that approached it. We decided to challenge the assumption that OB below a concentration of 5 are not detectible. Experiments were conducted with diluted samples that are smaller than 5. The results indicate that the methodology works fine even if the initial concentration was less than 5. Thus it is possible that this methodology can be used in a quantitative manner, rather than as a presence or absence indicator as is traditionally done. In our work we treat optical brighteners semi quantitatively by assessing samples even if they were less than 5ug/l and using the initial concentration as our OB metric.

Outreach Comments

A GIS datalayer of the final mapped septic fields developed by this project was provided to Dr. Greg Boyer, Director of the NYS Great Lakes Watershed Consortium, to assist in his study of septic field inputs on the shore of Sodus Bay.

Student Training

Activities from this research was used to support one graduate student, and two undergraduate students. The graduate student performed all the water quality analysis including Optical Brighteners and assisted in GIS and Remote sensing for the research. The undergraduate students performed field work including sampling, flow measurements, and assisted in water quality analysis. This research formed the basis of last year's Air and Water Pollution Class Field Trip. A total of 12 students participated in this trip in which all students has to sample and collect data for the project.

References

Cao, Y., Griffith, J.F., and S.B. Weisberg. 2009. Evaluation of optical brightener photodecay characteristics for detection of human fecal contamination. Water Research 9:145-152.

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