New York State Water Resources Institute
Annual Technical Report
FY 2011

Introduction

The Mission of the New York State Water Resources Institute (WRI) is to improve the management of water resources in New York State and the nation. As a federally and state mandated institution located at Cornell University, WRI is uniquely situated to access scientific and technical resources that are relevant to New York State's and the nation's water management needs. WRI collaborates with regional, state, and national partners to increase awareness of emerging water resources issues and to develop and assess new water management technologies and policies. WRI connects the water research and water management communities. Collaboration with New York partners is undertaken in order to: 1) Build and maintain a broad, active network of water resources researchers and managers, 2)Bring together water researchers and water resources managers to address critical water resource problems, and 3)identify, adopt, develop and make available resources to improve information transfer on water resources management and technologies to educators, managers, and policy makers.

Research Program Introduction

The NYS WRI's FY11 competitive grants research program was conducted in partnership with the NYS Department of Environmental Conservation and the Hudson River Estuary Program (HREP). The specific areas of interest for the FY2011 grants program were: 1) Research that addresses key knowledge gaps or issues of emerging importance to New York’s water resources; 2) Projects that integrate scientific, legal, planning and/or social expertise to build comprehensive strategies for watershed management; and3) Novel outreach methods that enhance the communication and impact of science-based innovation to water resource managers and the public. Projects were evaluated by a panel consisting of representatives of the US Geological Survey, the NYS Department of Environmental Conservation (DEC), and faculty from Cornell University. In total, three research projects were supported in FY11 through the competitive grants program with a total funding level of $60,000. These projects included:

1. Reach-scale patterns in hyporheic exchange at pristine, degraded, and restored rivers. PIs: Dr. Theodore Endreny & Dr. Chuck Kroll, SUNY Environmental Science & Forestry.

2. Nitrogen (N) availability as driver of methylmercury production in forested soils and stream sediments. PI: Dr. Philippe Vidon, SUNY Environmental Science & Forestry.

3. Two-dimensional river model for predicting bacterial contamination of bathing beaches in the St. Lawrence River. PI: Dr. Michael Twiss, Clarkson University.

NITROGEN (N) AVAILABILITY AS DRIVER OF METHYLMERCURY PRODUCTION IN FORESTED SOILS AND STREAM SEDIMENTS

Basic Information

Title:	NITROGEN (N) AVAILABILITY AS DRIVER OF METHYLMERCURY PRODUCTION IN FORESTED SOILS AND STREAM SEDIMENTS
Project Number:	2011NY161B
Start Date:	6/1/2011
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	25
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Toxic Substances, Nitrate Contamination
Descriptors:	
Principal Investigators:	Philippe Gilles Vidon

Publications

There are no publications.

Annual Report for NYWRRI Award # 64038-9616

NITROGEN (N) AVAILABILITY AS DRIVER OF METHYLMERCURY PRODUCTION IN FORESTED SOILS AND STREAM SEDIMENTS

Start / End dates: 03/11-02/13
(a 1-year no-cost extension was granted to SUNY-ESF in May 2012)

Principal Invesigators: P. Vidon and M. Mitchell.

Objectives

Atmospheric deposition of nitrogen (N), sulfur (S) and mercury (Hg) is ubiquitous in the Northeastern United States and has a major impact on forest lands and water quality of this region. However, although recent research suggests significant interactions exist between the N, S and Hg cycles in forested landscapes, the exact nature of the complex interactions between these cycles is still poorly understood.

For this project, our objectives are to:

1) Determine to what extent nitrate availability in soils and streams regulate S, Hg and MeHg export at the forest watershed scale across a range of seasonal and hydrological conditions (e.g., low flow versus high flow)

2) Determine to what extent nitrate availability in forest soils and associated wetland sediments regulate S, Hg and methylmercury (MeHg) availability across a range of redox conditions, from headwater locations (oxic) to stream hyporheic zones, and lowland wetland soils (anoxic).

Addressing these objectives is critical to the management of our forest as climate and rates of N, S and Hg atmospheric deposition are constantly changing. Understanding how various levels of N affect S and Hg cycling in these watersheds in relation to changes in hydrological and redox conditions in soils and streams will help **1)** better predict how future changes in climate and atmospheric deposition might affect N, S, and Hg dynamics, and **2)** identify areas of the landscape that are especially sensitive to N, S or Hg contamination and where management should be focused.

Activity Report

Because FY2011 funds did not become available to the PIs before the middle of August 2011, it was decided that the project will be delayed one year in order to capture N, S and Hg dynamics in spring, a critical time of year for Hg export. A one-year no-cost extension was granted by the NYWRRI to SUNY-ESF in May 2012 until 02/2012.

To date, sampling for a suite of hydrological and biogeochemical parameters started in May 2012 in two SUNY-ESF owned Adirondack research catchments locally known as S14 (3.0 ha) and S15 (2.4 ha)(http://www.esf.edu/aec/). Although adjacent to each other, these catchments present very different level of nitrate in stream water, with S14 having high nitrate concentrations (0.4-0.9 mg/L) and S15 low nitrate concentrations in stream water (0.2-0.4 mg/L). These monitoring efforts are complemented by the monitoring of Archer Creek (135 ha), which encompasses catchments S14 and S15, in order to integrate the measurements from S14 and S15 and have access to a broader range of redox conditions.

We are currently measuring the following parameters on a biweekly basis: stream flow, water table depth, soil moisture, pH, dissolved oxygen, oxido-reduction potential, NO_3^-, NH_4^+, dissolved organic carbon (DOC), total mercury (THg), methylmercury (MeHg), and SO_4^{2-}/S^{2-}.

Graduate and Undergraduate Student Training (1 Graduate Student, 2 Undergraduate Students)

This research project forms the basis of the MS Thesis for Whitney Carleton, graduate student in the Department of Forest and Natural Resources Management at SUNY-ESF under the supervision of PI Vidon.

Whitney started her MS project in Fall 2011 and is currently in charge of conducting most of the fieldwork. Whitney is expected to graduate from SUNY-ESF after completion of this research project in Spring 2012.

In Spring 2012, Whitney presented an overview of the project at a local conference:

Carleton, W., P. Vidon, M. Mitchell, 2012. Total mercury and methylmercury dynamics: Stream export in an upland-forested watershed in the Adirondack region of New York State. SUNY-ESF Spotlight on Research 2012 Conference, Syracuse, NY, April, 2012.

In addition to Whitney, two undergraduate students (Joshua Enck and Angela Marcoccia) will be directly involve in this project this summer and will use some of the data collected as part of this project as the basis of the Senior Thesis to be completed in Spring 2012.

Reach-Scale Patterns in Hyporheic Exchange at Pristine, Degraded and Restored Rivers

Basic Information

Title:	Reach-Scale Patterns in Hyporheic Exchange at Pristine, Degraded and Restored Rivers
Project Number:	2011NY162B
Start Date:	6/1/2011
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	25
Research Category:	Engineering
Focus Category:	Solute Transport, Groundwater, Hydrology
Descriptors:	
Principal Investigators:	Theodore Endreny, Chuck Kroll

Publications

There are no publications.

WRI Grant 2011 Final Report

Title:

Reach-Scale Patterns in Hyporheic Exchange at Pristine, Degraded and Restored Rivers

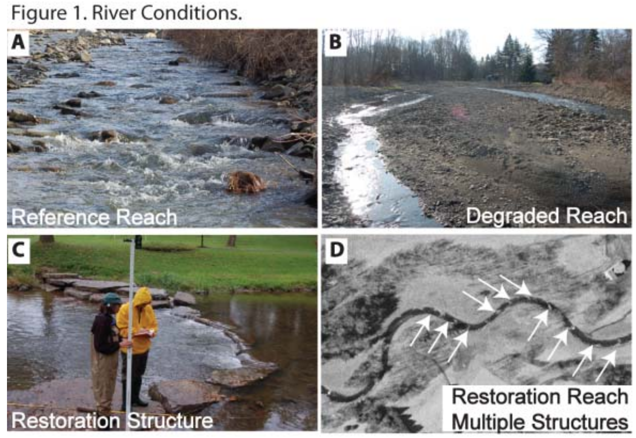
Faculty, Student, and Agency Participants:

Dr. Ted A. Endreny, Professor & Chair, Department of ERE, SUNY ESF
Dr. Chuck N. Kroll, Professor, Department of ERE, SUNY ESF
Joe Becker, M.S. student, Department of ERE, SUNY ESF
Hanh Chu, M.S. student, Department of ERE, SUNY ESF
Mike Fay, M.S. student, Department of ERE, SUNY ESF
Jesse Robinson, M.S. student, Department of ERE, SUNY ESF
Marty Briggs, PhD student, Department of Earth Sciences, Syracuse University
Mark Vian, Project Manager, NYC Department of Environmental Protection (DEP)
Elizabeth Reicheld, Director, Stream Management, NYC DEP
Judd Harvey, United States Geological Survey

Problem and Research Objectives

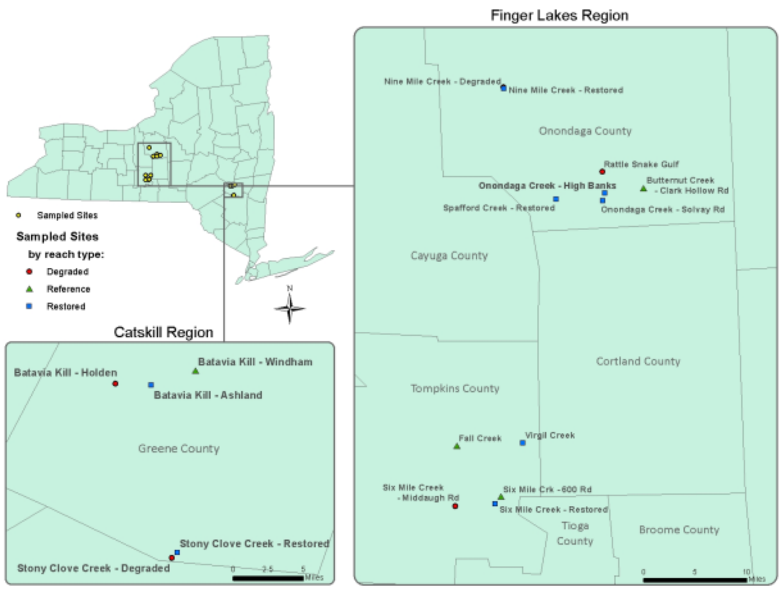
New York is home to between 100 and 200 natural channel design (NCD) restoration projects (Derrick, 2010; Reichheld, 2010; Schwartz, 2010). The projects involve identifying morphological reference (aka pristine) reaches as a restoration target for morphologically degraded reaches, and using restoration structures to control the morphological change (**see Figure 1 illustration**). To achieve water quality and fishery enhancement goals NY has paid more than $30 million for NCD projects (i.e., restoration reaches extend 100s to 1000s of meters at a cost of $200 to $3000 per reach meter) (Nagle, 2007). Despite a national debate on the efficacy of NCD (Lave, 2009; Malakoff, 2004) and informal observations that 30% of NY projects may have partly failed (Nagle, 2007), NY has had no systematic and scientifically accepted assessment of NCD restoration performance. An assessment of NCD performance will help justify continued funding or modify project approaches. This research was conducted to assess how the key river function of transient storage differed between the degraded, pristine, and NCD restored reaches, and thereby inform and advance river restoration (Bernhardt et al., 2005; Giller, 2005).

Figure 1. River Conditions.



Our goal was to use transient storage modeling (TSM) to quantify surface and subsurface storage parameters, including residence time distributions (RTD). Subsurface storage exchange is referred to as hyporheic exchange flux (HEF). HEF creates a mixing of water and solutes through the riverbed (Boulton et al., 2010; Harvey and Wagner, 2000) and is an indicator of water quality and fishery functions (Hall et al., 2002). The geographic scope of our project included NYs Finger Lakes and Catskill hydrologic regions (**see sites in map below**). Our project question was: *Are the reach-scale HEF metrics different between morphologically restored, degraded, and pristine reaches?*

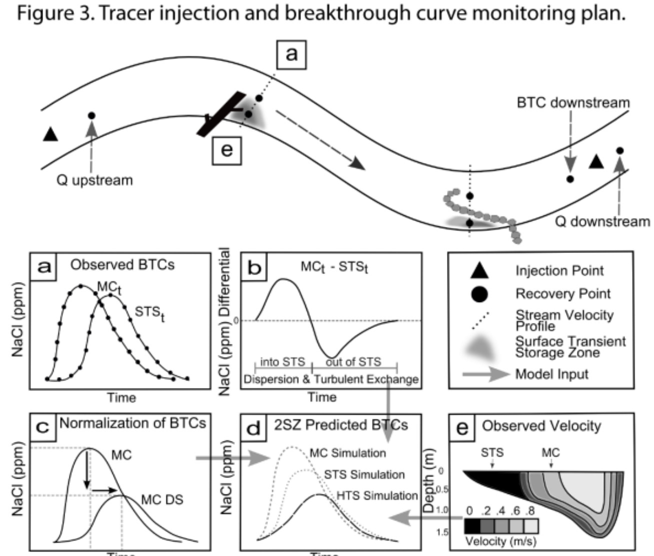
Project objectives were: (A) Identify sample reaches and collect breakthrough curve (BTC) data. (B) Analyze breakthrough curve data with TSM tools. (C) Statistically characterize the variability of TSM and associated HEF metrics. (D) Disseminate results and assess project performance relative to student training, agency partnerships, and transferability of methods and information.



Methods & Procedures

We used discussions with restoration teams (Derrick, 2010; Reichheld, 2010; Schwartz, 2010) to identify NCD restored, degraded, and pristine sites. We then performed NaCl tracer injections outlined by the Stream Solute Workshop (Aumen and Stream Solute Workshop, 1990) with coordinated BTC recovery using HOBO data loggers following guidance from M. Briggs, whose methods are illustrated in **Figure 3** (Briggs et al., 2009). We sampled 12 NCD restoration reaches (8 shown in map), defined by morphologic features typical of a pristine riffle-pool reach (Rosgen, 2006; Smith and Prestegaard, 2005) and with in-channel structures. We sampled 4 degraded reaches, defined to exhibit elevated instability and/or no significant bedform features. We sampled 4 reference reaches, defined to exhibit morphological equilibrium. Each reach was mapped, photographed, and surveyed to characterize cross-sections, longitudinal profiles, sinuosity, and sediment substrate. HOBO probes were inserted at the upstream

Figure 3. Tracer injection and breakthrough curve monitoring plan.



and downstream ends of the channel to set a reach length, *L*, and based on engineering judgement this *L* should be adequate to capture hyporheic mixing. After the BTCs were collected we tested the adequacy of mixing by computing dimensionless Damkohler (Da) numbers (Wagner and Harvey, 1997) for each reach; Da is a ratio of exchange rate to mass transport rate. The *L* is ideal when the Da is 1, and considered acceptable when between 0.1 and 10

Observed BTCs were analyzed for the main channel (MC) and surface transient storage (STS) using VBA macros. The BTCs were processed with the following TSM methods: a) the USGS one-dimensional transport with the inflow and storage (OTIS) 1 zone model (Runkel, 1998) that lumps surface and subsurface hyporheic storage into a single transient parameter, b) the OTIS 2 zone model (Briggs et al., 2009) and the Weiner filter {Gooseff, 2011 #2442} that both allows separation of the surface and subsurface transient storage, and c) the STIR TSM that fits probability density functions to determine the RTDs (Marion et al., 2008), to extract 9 distinct HEF metrics. The OTIS and STIR models represent the advection-dispersion equation (ADE) with transient storage (Bencala and Walters, 1983; Runkel, 1998) and generated estimates of an exchange rate coefficient (α) and transient storage cross-section area (A_s). The OTIS model runs were optimized with the non-linear regression package UCODE_2005 (Poeter et al., 2005).

Principle Findings and Significance

1. Objective A: We created the first reported database of BTC analysis for NCD restored reaches in the Finger Lakes / Central New York and Catskills. The team created a protocol for site selection that will be published as part of a MS thesis and possibly be submitted for refereed publication. We initially concluded the BTC data were robust based on Damkohler numbers between 0.1 and 10 for our BTCs, which suggested we had adequate mixing length. We later determined most of our BTC data were not robust due to unmixing of the solute by the rock vane structures. We observed and measured large eddies of surface transient storage generated by vane structures in the restored reaches (**see extent of dye mixture change from full to half channel at j-hook vane**). These transient storage zones were not present in the degraded or pristine reaches. We are excited to document these differences in transient storage between morphological reach types and to document that laterally mixed rivers can become instantly unmixed due to NCD structures.

2. Objective B1: We analyzed the BTC data with the OTIS 1 zone model. We had N=12 NCD restored reaches and analyzed OTIS 1 zone TSM patterns; the sample sizes for degraded (N=4) and pristine (N=4) reaches were too small to analyze TSM patterns. The low sample sizes were due in part to a delay in the project start (funding arrived late), rain events

prohibiting site visits later in the summer, and a persistently wet fall (tropical storms Irene and Lee, etc.). We found differences in the NCD restored TSM hyporheic exchange rate, q, compared to rates published for pristine reaches. The OTIS 1 zone results, however, are spurious because the OTIS model fit required simulation of large lateral inflows that suggested the reach gained 50% additional discharge. We have worked with USGS personnel Jud Harvey and Rob Runkel to analyze this problem; Runkel has written new OTIS code to handle our larger data sets (monitoring at 2 s) and Harvey has identified follow-on experiments to clarify if the anomalous model inflow can be used to estimate STS. We are working with an ESF PhD student (Tian Zhou) who is employing a computational fluid dynamic (CFD) model to analyze this unmixing issue. We have a publication in development on these OTIS 1 zone and lateral unmixing issues.

3. Objective B2: We were unable to analyze the BTC data with the OTIS 2 zone model because the methods published by the OTIS 2 zone developers are not robust for NCD restored reaches with large eddies. In NCD restored reaches the river is not clearly separated into a MC zone and STS zone, and we instead have multiple zones where NaCl is transiently residing. We were also able to document that the Weiner filter 2 zone TSM method (Gooseff et al., 2011) for analyzing MC and STS exchange is not robust for reaches with large eddies. Our results suggest the current methods for 2 zone TSM analysis are incapable of handling large eddies, which is a common river condition in NCD channels. We have a publication in development on the limitations of the OTIS 2 zone and Weiner filter methods.
4. Objective B3: We were unable to analyze the BTC data with the STIR model because of the lateral unmixing of the NaCl injection. In our effort to process the BTC data in STIR we thought the STIR model would need to simulate lateral inflow, and we worked with Andrea Bottacin-Busolin to write a new version of STIR that can simulate lateral inflow. This is a major upgrade of the STIR model that is now publically available.
5. Objective C: We did not statistically test for differences in transient storage between the three morphological conditions (restored, degraded, pristine) due to inadequate sample sizes and problematic data (as explained in point 2 above). We have follow-on funding from an EPA STAR award to our ESF MS student Jesse Robinson to complete this sampling and statistical testing with improved injection and recovery methods.
6. Objective D: We have disseminated our results with key university, USGS, and NYC DEP personnel through conference proceedings, meetings, and email/phone conversations; we are writing manuscripts and theses to: a) further disseminate the results, b) improve on sensitive field methods, and c) distinguish between TSM in the 3 river morphologies. We have trained 4 ESF MS students in field methods and worked to inform 4 agency personnel on the issues of TSM monitoring and modeling in NYS rivers. We anticipate greater impacts as our results are published.

Publications and Conference Proceedings

Becker, J., T. Endreny, et al. Vane induced lateral unmixing of slug injections and impacts on transient storage modeling. *Water Resources Research*, In preparation.

Becker, J., T. Endreny, et al. The myth of the single surface storage zone in restored rivers. *Hydrological Processes*, In preparation.

Becker, J., J. Robinson, T. Endreny, et al., Reach scale transient storage characteristics of upstate NY stream restoration projects. *Journal of the American Water Resources Association - JAWRA*, In preparation.

Becker, J. Reach scale transient storage characteristics of upstate NY stream restoration projects, *Presentation at SUNY ESF ERE 797 Research Methods Seminar*, Syracuse, NY November 11, 2011.

Endreny, T. Impacts of river restoration on hyporheic exchange, *Presentation at SUNY ESF ERE 797 HydroBioGeo Seminar*, Syracuse, NY March 6, 2012

Robinson, J. et al. Desktop and field methods to rapidly characterize morphologically pristine, degraded, and restored river reaches, International *Journal of River Basin Management,* In preparation.

New Projects Resulting from WRI Grant

This WRI grant development helped ESF MS student Jesse Robinson win an EPA STAR fellowship. The WRI grant resulted in the SUNY ESF ERE Department purchasing 10 HOBO data loggers, which have been used to support additional river and flume studies. The WRI grant results were used to partially motivate NSF REU funding to support ongoing NSF work on hyporheic exchange at river restoration sites.

References

Aumen N.G., Stream Solute Workshop. 1990. Concepts And Methods For Assessing Solute Dynamics In Stream Ecosystems. Journal of the North American Benthological Society 9:95-119.

Bencala K.E., Walters R.A. 1983. Simulation of Solute Transport in a Mountain Pool-and-Riffle Stream: A Transient Storage Model. Water Resources Research 19:718-724.

Bernhardt P.M.A., Alexander A.J.D., Barnas G.K., Brooks S., Carr J., Clayton S., Dahm C., Follstad-Shah J., Galat D., Gloss S., Goodwin P., Hart D., Hassett B., Jenkinson R., Katz S., Kondolf G.M., Lake P.S. 2005. Synthesizing River Restoration Efforts. Science 308:636-637.

Boulton A.J., Datry T., Kasahara T., Mutz M., Stanford J.A. 2010. Ecology and management of the hyporheic zone: stream-groundwater interactions of running waters and their floodplains. Journal of the North American Benthological Society 29:26-40. DOI: 10.1899/08-017.1.

Briggs M.A., Gooseff M.N., Arp C.D., Baker M.A. 2009. A method for estimating surface transient storage parameters for streams with concurrent hyporheic storage. Water Resources Research 45:13. DOI: 10.1029/2008wr006959.

Derrick D. 2010. USACE Stream Restoration Project Plans for 2011, Personal Communication, November 2011, Syracuse, NY.
Giller P.S. 2005. River restoration: seeking ecological standards. Editor's introduction. Journal of Applied Ecology 42:201-207. DOI: 10.1111/j.1365-2664.2005.01020.x.
Gooseff M.N., Benson D.A., Briggs M.A., Weaver M., Wollheim W., Peterson B., Hopkinson C.S. 2011. Residence time distributions in surface transient storage zones in streams: Estimation via signal deconvolution. Water Resour. Res. 47:W05509. DOI: 10.1029/2010wr009959.
Hall R.O., Bernhardt E.S., Likens G.E. 2002. Relating nutrient uptake with transient storage in forested mountain streams. Limnology and Oceanography 41: 255-265.
Harvey J.W., Wagner B.J. 2000. Quantifying Hydrologic Interactions between Streams and Their Subsurface Hyporheic Zones, in: J. B. Jones and P. J. Mulholland (Eds.), Streams and Ground Waters, Elsevier, San Diego, CA. pp. 3-44.
Lave R. 2009. The Controversy Over Natural Channel Design: Substantive Explanations and Potential Avenues for Resolution. Journal of the American Water Resources Association 45:1519-1532. DOI: 10.1111/j.1752-1688.2009.00385.x.
Malakoff D. 2004. Profile: The River Doctor. Science 305:937-939.
Marion A., Zaramella M., Bottacin-Busolin A. 2008. Solute transport in rivers with multiple storage zones: The STIR model. Water Resour. Res. 44. DOI: 10.1029/2008wr007037.
Nagle G. 2007. Evaluating Natural Channel Design Stream Projects. Hydrological Processes 21:2539-2545.
Poeter E.E., Hill M.C., Banta E.R., Mehl S.W., Christensen S. 2005. UCODE_2005 and Six Other Computer Codes for Universal Sensitivity Analysis, Calibration, and Uncertainty Evaluation, Constructed using the JUPITER API, US Geological Survey, Reston, VA.
Reichheld B. 2010. NYC DEP Stream Restoration Project Plans for 2011, Personal Communication, November 2011, Syracuse, NY.
Rosgen D.L. 2006. River Restoration using a Geomorphic Approach for Natural Channel Design, Proceedings of the Eighth Federal Interagency Sedimentation Conference, August 2-6, 2006, Reno, Nevada.
Runkel R.L. 1998. One dimensional transport with inflow and storage (OTIS): A solute transport model for streams and rivers, U.S. Geological Survey, Denver, CO. pp. 70.
Schwartz C. 2010. USFWS Stream Restoration Project Plans for 2011, Personal Communication, November 2011, Syracuse, NY.
Smith S.M., Prestegaard K. 2005. Hydraulic Performance of a Morphology-Based Stream Channel Design. Water Resources Research 41:17pp, doi:10.1029/2004WR003926.
Wagner B.J., Harvey J.W. 1997. Experimental design for estimating parameters of rate-limited mass transfer: Analysis of stream tracer studies. Water Resources Research 33:1731-1741.


Figure of team members mixing NaCl slugs for the tracer experiment.


Figure of the team monitoring the flow in a NCD restored reach upstream of a j-hook.

Figure of the team measuring the pool depth in a NCD restored reach downstream of a j-hook.

Figure of the team measuring channel thalweg distance in a degraded reach.

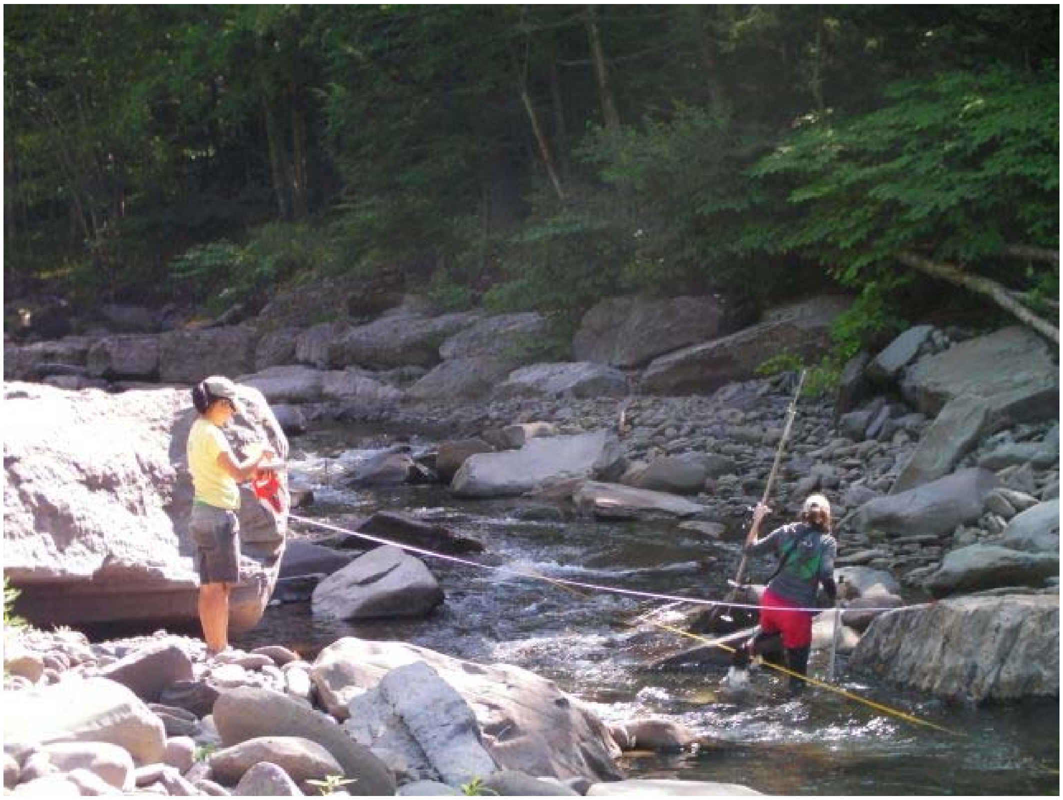


Figure of the team working around a large cross-vane in a NCD restored reach.

Figure of the team waiting for the NaCl slug to pass through the river reach, and thumbs up to WRI for a great summer experience!

Two-Dimensional River Model for Predicting Bacterial Contamination of Bathing Beaches in the St. Lawrence River

Basic Information

Title:	Two-Dimensional River Model for Predicting Bacterial Contamination of Bathing Beaches in the St. Lawrence River
Project Number:	2011NY165B
Start Date:	6/1/2011
End Date:	8/31/2012
Funding Source:	104B
Congressional District:	23
Research Category:	Water Quality
Focus Category:	Surface Water, Non Point Pollution, Models
Descriptors:	
Principal Investigators:	Michael Twiss

Publications

There are no publications.

Interim report t the New York State Water Research Institute.

Project title: Two-Dimensional River Model for Predicting Bacterial Contamination of Bathing Beaches in the St. Lawrence River

Principal investigators names and institutions.

- Dr. Michael R. Twiss, Professor of Biology & Director of Great Rivers Center at Clarkson University, Potsdam, NY, 13699, email: mtwiss@clarkson.edu; tel. 315-268-2359
- Dr. Joesph Skufca, Associate Professor of Mathematics & Computer Science, Clarkson University, email: jskufca@clarkson.edu; tel. 315-268-2399
- Dr. Jeffrey J. Ridal, Executive Director, St. Lawrence River Institute of Environmental Sciences, 2 Belmont Street, Cornwall, ON, Canada K6H 4Z1, email: jridal@riversintitute.ca; tel. 613-936-6620

Field sampling in 2011 - In our initial ten week study,(June 16th to August 18th, 2011), water samples were collected from various locations along the St. Lawrence River in order to develop a predictive model of bacterial contamination at Coles Creek State Park Beach. Samples were collected four days a week, Monday through Wednesdays at 5 locations and 6 locations on Thursdays, from 9:30am to 11:00am. The locations sampled, starting the farthest upstream, were Red Mills Tributary, Lisbon Beach (Thursday's only), Iroquois Dam, Sucker Brook, Brandy Brook and finally, Coles Creek State Park Beach. These locations were selected based on a two-dimensional river flow model that estimated Red Mills Tributary's water to take roughly one day to reach Coles Creek State Park Beach.

Upon arriving at the location, water temperature was determined and a water sample collection made from the surface and placed in a cooler. Samples were brought back to the lab for immediate analysis, with the longest wait time before analysis being two hours after initial sampling. The first part of the analysis was to give the samples a gentle mix and plate 1mL of the sample on to a Petri Film (3M) that is specific for coliforms. Red Mills Tributary had to undergo a 10-fold dilution before plating because of high numbers of bacteria in the water. Plating was done in triplicate for each location and then incubated for 24 hours at 37°C. Counts were then done after the 24 hours to determine the number of *Escherichia coli* and total coliforms (all coliforms including *E. coli*) with *E. coli* being distinguished by the selective and differential medium that was used. After plating was completed more water quality tests were administered to determine the specific conductivity (using an electronic YSI sonde), turbidity (measured using a spectrophotometer at 750 nm with a 5cm cuvette and colored dissolved organic matter (CDOM) y fluorimetry, in addition to a measurement of total phosphorus.

Data Synthesis and Analysis in 2011: Mathematical Modeling Techniques - As our foundational mathematical goal, we wanted to develop a *methodology* that could be used to predict *E. coli* levels at a beach, where we specifically intend for this methodology to allow for either now-casting (based on immediately available factors) or forecast (based on previous days values). As such, we take as explanatory variables a number of measured quantities deemed to be biologically relevant, measured at the beach site. Additionally, we used river flow models (2-D) to estimate "day-ahead" sources of water at the beach, and made water quality measurements at these specified upstream locations. As a third source of available explanatory measurements, we consider weather information (wind, rainfall, temperature), available from Crysler Beach, ON, which is located 7.4 km from Coles Creek State Park Beach. Mathematically, our goal was to determine a prediction function

$$y = f(x_1, x_2, \dots, x_n)$$

that could predict beach *E. coli* level y as a function of the explanatory variables.

Our general approach was to consider both regression models (linear and nonlinear), which could predict a *bacteria level*, logistic regression models, predicting a *likelihood of exceeding a safe level*, and classifiers, predicting whether we are *above or below* some threshold. For each models explored, we had to make a selection of which predictor variables to include in the model. Although it might seem that better models could be achieved through inclusion of all the variables, it is reasonably easy to imagine that if a predictor variable was not very important, it could add "noise" to prediction without adding much power to the predictive performance. As such, we desired to determine which predictor variables are most important to the modeling process. Our algorithm in evaluating these models is outlined as follows:

1. Assume a basic model structure
2. Choose a subset of explanatory variables
3. Choose model parameters (regression coefficients, for example) that minimize model error and measure performance
4. Evaluate performance of that subset of variables by using a cross-validation procedure.
5. Repeat steps 2-4 to exhaustively search all subsets of explanatory variables to determine the most robust set of variables for that model structure
6. Repeat steps 1-6 for other model structures.

From our preliminary modeling effort, we draw the following main conclusions:

- Linear Regression performed very poorly, indicating likely non-linear dependence on explanatory variables.
- K-Nearest Neighbor classifier (a simple, non-linear approach) appears to be the most robust of the models studied.

- For the beaches under study, upstream tributaries are the likely source of the bacterial contamination.
- Key variables in predicting next day beach levels are conductivity and bacteria level at the upstream tributary, along with current and previous day rainfall.

Our initial analysis was based on data measured within this funded study. Additionally, we applied a similar result on collaborator data collected at Canadian beaches during a previous summer (provided by Dr. Jeff Ridal, St. Lawrence River Institute of Environmental Sciences). The approach to identify a good model seems to have worked well on these datasets. However, the approach must be viewed as "exploratory data analysis" in that we are considering all possible models before evaluating performance.

Work in 2012 - Our intention for this summer is to validate and refine the best of the predictive mathematical models. In addition, we will conduct event sampling with intensive sampling to be conducted at Red Mills Tributary and Coles Creek State Park Beach. Sampling at these locations will bracket a significant rainfall event in order to illustrate how water quality changes over time as runoff occurs, and contaminated water is entrained and moved downstream.

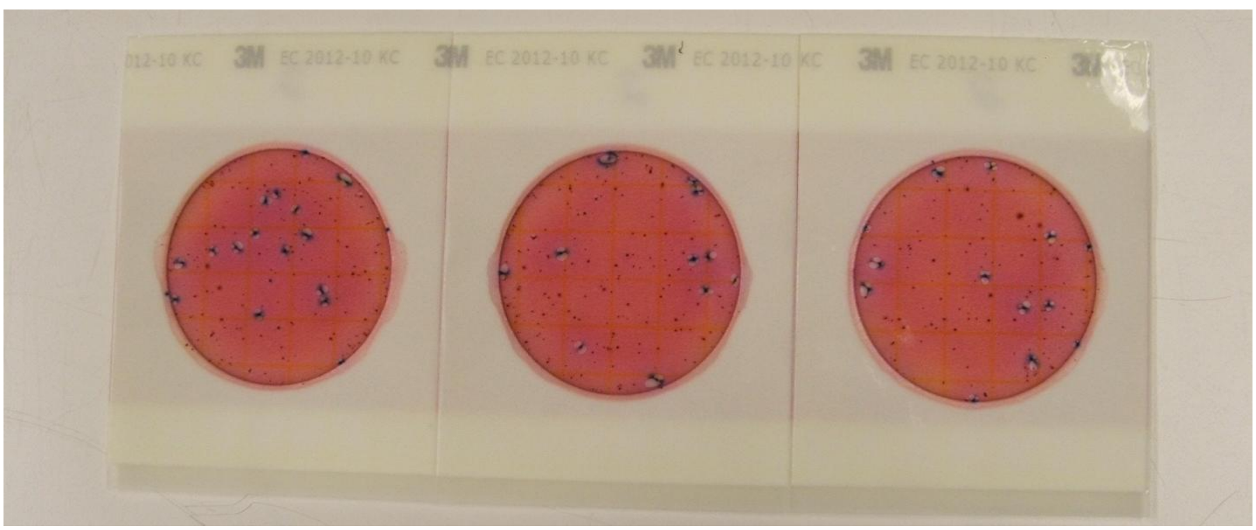


Figure. Coliform (red colonies) and *Escherichia coli* (purple colonies with gas bubbles) on differential and selective agar used to enumerate fecal bacteria in river water. These are three replicates from Red Mills tributary that were derived from 1 mL of a 10-fold dilution of water, showing abundant bacteria present that enter into the shoreline waters of the St. Alwrence River.

USGS Award No. G11AP20223 Flood Frequency Research for California

Basic Information

Title:	USGS Award No. G11AP20223 Flood Frequency Research for California
Project Number:	2011NY177S
Start Date:	9/1/2011
End Date:	8/31/2012
Funding Source:	Supplemental
Congressional District:	
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Floods, Surface Water
Descriptors:	
Principal Investigators:	Jery Stedinger

Publication

1. Lamontagne, Jonathan R., Jery R. Stedinger, Charles Berenbrock, Andrea G. Veilleux, Donna L. Knifong, and Justin C. Ferris, 2012, Development of Regional Skews for Selected Flood Durations for the Central Valley Region, California, Based on Data Through Water Years 2008–9, U.S. Geological Survey Scientific Investigations Report in cooperation with U.S. Army Corps of Engineers, Under Review.

Development of Regional Skews for Selected Flood Durations for the Central Valley Region, California, Based on Data Through Water Years 2008–9

By Jonathan R. Lamontagne[1], Jery R. Stedinger[1], Charles Berenbrock[2], Andrea G. Veilleux[3], Donna L. Knifong[2], and Justin C. Ferris[2]

Abstract

Flood-frequency information is important in the Central Valley Region of California because of the high risk of catastrophic flooding. Most traditional flood-frequency studies focus on peak flows, but for the assessment of the adequacy of reservoirs, levees, other flood control structures, sustained flood flow (flood duration) frequency data are needed. This study focuses on rainfall or rain-on-snow floods, rather than the annual maximum, because rain events produce the largest floods in the region. A key to estimating flood-duration frequency is determining the regional skew for such data. Of the 50 sites used in this study to determine regional skew, 28 sites were considered to have little to no significant regulated flows, and for the 22 sites considered significantly regulated, unregulated daily flow data were synthesized by using reservoir storage changes and diversion records. The unregulated, annual maximum rainfall flood flows for selected durations (1-day, 3-day, 7-day, 15-day, and 30-day) for all 50

[1]Cornell University, School of Civil & Environmental Engineering, 220 Hollister Hall, Ithaca, New York 14853

[2]U.S. Geological Survey, California Water Science Center, Placer Hall, 6000 J Street, Sacramento, California 95819

[3]U.S. Geological Survey, Office of Surface Water, 12201 Sunrise Valley Drive, Reston, Virginia

sites were furnished by the U.S. Army Corp of Engineers. Station skew was determined by using the expected moments algorithm program for fitting the Pearson Type 3 flood-frequency distribution to the logarithms of annual flood-duration data.

Bayesian generalized least squares regression procedures used in earlier studies were modified to address problems caused by large cross correlations among concurrent rainfall floods in California and to address the extensive censoring of low outliers at some sites by using the new expected moments algorithm for fitting the LP3 distribution to flood-duration data. To properly account for these problems and to develop suitable regional-skew regression models and regression diagnostics, a combination of ordinary least squares, weighted least squares, and Bayesian generalized least squares regression was adopted. This new methodology determined that a nonlinear model relating regional skew to mean basin elevation was the best model for each flood duration. The regional-skew values ranged from -0.74 for a flood duration of 1-day and a mean basin elevation less than 2,500 feet to values near 0 for a flood duration of 7-days and a mean basin elevation greater than 4,500 feet. This relation between skew and elevation reflects the interaction of snow and rain, which increases with increased elevation. The regional skews are more accurate and the mean squared errors are less than in the National skew map of Bulletin 17B.

Information Transfer Program Introduction

None.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	0	3
Masters	3	0	0	1	4
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	6	0	0	1	7

Notable Awards and Achievements