A workshop titled “Diurnal (Diel) Cycling of Chemical Constituents in Surface Water and Related Media—Scientific and Regulatory Considerations” was cosponsored by the N.J. Department of Environmental Protection, U.S. Geological Survey, and the Water Resources Research Institute-Rutgers, and held at NJDEP on December 12, 2008.

The aim of the workshop was to present and discuss

• Causes of diurnal cycling of a variety of chemical constituents;
• What such cycles mean to data-collection efforts.
Which Constituents Cycle and Why
Diel processes in streams: Overview

Chris Gammons, Montana Tech

- Sunlight
- Temperature
- Streamflow
- Suspended solids
- pH
- Hardness
- Dissolved oxygen
- Seasonal changes
- Lakes vs. rivers
Diel changes in pH

- pH changes are greatest for high-productivity streams with neutral to alkaline pH
- pH maxima in mid- to late afternoon, minima at dawn (similar to water temperature)

3 streams near Anaconda, MT
Gammons et al., 2007a
Diel Cycles: Dissolved Arsenic and Metals

David Nimick
U.S. Geological Survey
Helena, Montana
Which Dissolved Metals?

High Ore Creek

Arsenic
22-33 ug/L
50%

Cadmium
1.4-3.0 ug/L
110%

Manganese
35-142 ug/L
306%

Zinc
214-634 ug/L
196%

(Nimick et al., 2003)
Diel cycling of nutrients
Chris Gammons, Montana Tech

Silver Bow Creek, Montana
Big Hole River, Montana
Harrison et al. (2005)

Diel variations in N species in a sewage-rich canal in Mexico

Like Silver Bow Creek, see decrease in NO$_3^-$ and increase in NH$_4^+$ at night. Water column anoxic at night.

Big swings in N$_2$O... possible role of rivers in global N$_2$O cycling?
Diel Patterns of Organic Matter Transport in a Pennsylvania Piedmont Stream

Louis A. Kaplan, David C. Richardson, J. Denis Newbold, and Anthony K. Aufdenkampe

Stroud Water Research Center
Diel Patterns

Graph showing diel patterns of Seston and POC (Particulate Organic Carbon) concentrations.

- **Seston**: Open circles, with a peak around 2:00 h on 21 Jun 06.
- **POC**: Filled squares, with a peak around 2:00 h on 21 Jun 06.

**Axes**:
- **Y-axis**: Seston (mg L⁻¹) and POC (mg L⁻¹)
- **X-axis**: Time (20:00 h to 8:00 h, 21 Jun 06 to 22 Jun 06)

**Legend**:
- Open circles: Seston
- Filled squares: POC

**Note**: The graph indicates a diurnal cycle with Seston concentrations peaking during the night and POC concentrations peaking during the day.
Case Studies
Diel Metal Cycles: Temporal Variability in Alkaline Streams

David Nimick
U.S. Geological Survey
Helena, Montana
Diel processes in low-pH streams

Chris Gammons, Montana Tech

Rio Tinto, Spain
Fisher Creek F1 site: pH ~ 3.3

- Daytime drop in total Fe (solubility of HFO ↓ as T ↑)
- Daytime photoreduction of Fe(III) to Fe(II)
Diurnal Cycling of Persistent Organic Pollutants in the Atmosphere

Lisa A. Rodenburg

Department of Environmental Sciences
School of Environmental and Biological Sciences
Rutgers, the State University of New Jersey
Diurnal variability of PCBs depends on location

PCBs higher during the day in remote areas (similar to Hornbuckle and Eisenreich 1996)

PCBs higher at night in urban areas

MacLeod et al ES&T 2007
Arsenic, Metals, and Nutrients in the Wallkill River, New Jersey: Natural and Induced Diurnal Cycles

Julia L. Barringer, Timothy P. Wilson, Zoltan Szabo, Jennifer L. Bonin, Jeffrey M. Fischer, Nicholas P. Smith

U.S. Geological Survey, New Jersey Water Science Center, in cooperation with the New Jersey Department of Environmental Protection
A set of cycles was observed for anions that has not, to date, been reported for other rivers. These cycles had two maxima, and coincided with a two-maximum diurnal cycle for specific conductance.

Variations in concentrations of chloride (Cl), nitrite + nitrate (NO$_2$+NO$_3$), and boron (B) over a 24-hour period, Wallkill River at WAL-4, September 2005.
Why Regulators and Scientists Need to Know About Diurnal Cycles
Diurnal Dissolved Oxygen Concentrations

Presented by
Marzooq Alebus
Division of Watershed Management
New Jersey Department of Environmental Protection
December 12, 2008
Diurnal Dissolved Oxygen (DO) Data Use in Water Quality Assessment

- Best measurement to assess compliance with SWQS for DO concentration – minimum DO concentrations do not usually occur between the hrs of 9AM and 12PM!
- Use as a response indicator of eutrophication - assessment of use impairment due to nutrient overenrichment
- Diurnal DO profile can be used to predict stream primary production rate, respiration and stream reaeration rates
Diel Metal Cycles:
Toxicity Considerations

David Nimick
U.S. Geological Survey
Helena, Montana
Why Would Fluctuating Metal Concentrations Be Less Toxic?

- Coincidence of metal and temperature cycles
  - Metal uptake is slower at lower temperature
  - Less metal binds to gill at lower temperature
- Detoxification faster than accumulation at lower concentrations
Bureau of Water Quality Standards & Assessment

• Produce the “New Jersey Integrated Water Quality Monitoring and Assessment Report.”

  - Fulfills Section 305(b) and 303(d) requirements under the CWA.

  - In context of this reporting - do use Diurnal Data.
Continuous Ambient Water Temperature Monitoring

HOBO Units
Monitoring Design

• Water Temperature Data Loggers will be deployed in various streams:
  - Areas expected to produce representative summer, ambient water temperatures
  - Free flowing areas will produce the most representative data
  - Several sites to reflect conditions generally unimpacted by development (reference sites)
  - Data loggers are secured to stream bottom with cinder blocks with the units positioned approx. 6 inches off the bottom
Continuous Diurnal D. O. Water Monitoring

Water Monitoring and Standards

Bureau of Freshwater and Biological Monitoring
Monitoring Design

- Automated monitoring/recording equipment will be deployed in various streams:
  - Dissolved oxygen, dissolved oxygen saturation, water temperature, specific conductance and pH are recorded every 30 minutes for 72 hours.
  - Monitoring is conducted during June, July, August and early September based on availability of personnel.
- Low D.O. conditions are exacerbated by hot summer temperatures and low flow conditions.
2 Volunteer Groups
Diurnal Monitoring

• Trout Unlimited

• Pequannock River Coalition
The PowerPoint presentations will be available as pdfs on the Water Resources Research Institute web site:

http://njwrri.rutgers.edu