# Groundwater key for trout as our climate warms

**By Matt Mitro**

Trout anglers and biologists alike recognize the importance of cold groundwater to coldwater streams and the trout that live therein. Today we also recognize the threat that a changing climate at the global scale poses to species whose distributions and life histories are critically dependent on temperature.

Special Groundwater Issue

How are climate, temperature, and groundwater linked? This is an important question, the answers to which will help fisheries managers develop and implement adaptation strategies to protect trout in our rapidly changing environment.

Temperature may be the most important factor that determines where trout can and cannot live. Trout are fishes that evolved in a coldwater environment. For stream classification purposes, we have found it useful to identify a temperature boundary for coldwater streams: maximum summer water temperatures that are typically below 72°F. The best trout waters have summer water temperatures much lower, in the range of 55-61°F, which for most salmonids is the optimum temperature for feeding and growth.

To understand the challenges we face with climate change, it is helpful to consider how different factors at different scales affect the coldwater stream environment.

Stream temperature is influenced by many factors, the most important of which for coldwater streams may be cold groundwater inputs. The geology of Wisconsin allows for cold groundwater inputs to streams throughout the state, particularly in the Driftless Area in southwestern Wisconsin and in central and northern parts of the state. Improvements in agricultural land use in recent years have led to improvements in groundwater recharge and higher base flows in many streams. Such improvements include the utilization of conservation tillage practices and the enrollment of land into the Conservation Reserve Program.

Stream restoration efforts have also been successful at fixing degraded channels so that coldwater inputs can be conserved over longer stream distances. Higher base flows have lowered summertime stream temperatures in many coldwater streams. Cold groundwater inputs to streams may therefore be an important buffer to a warming climate.

### Global warming threat to trout

Despite the positive influence of groundwater on stream temperature, warming air temperatures associated with changes in global climate pose a significant threat to stream trout populations. Changes in stream temperature tend to track changes in air temperature. This relationship has proved useful in developing models to predict water temperature, and hence fish distribution, in Wisconsin streams.

I am currently working with other scientists in the Wisconsin DNR and USGS to improve our stream temperature and fish distribution models by better accounting for linkages between precipitation, groundwater, and stream temperature. With these improved models we will be able to better identify coldwater refugia in streams across the state, to explore the potential effects of climate change on coldwater streams and fishes in Wisconsin, and help to develop fisheries management adaptation strategies in response to climate change.

### What prediction models say

The University of Wisconsin-Madison Center for Climatic Research has recently released climate model predictions for Wisconsin. We can expect to see by the mid-21st century warmer average temperatures across Wisconsin, with greater increases in winter (5-11°F) versus summer (3-8°F). This predicted warming will include an increase in the number of days in which the daily high temperature exceeds 90°F.

The models also predict an increase in precipitation in winter (there is currently no consensus on how precipitation may change at other times of the year in Wisconsin) and an increase in the frequency of extreme precipitation events (precipitation events of at least two inches). Details on climate predictions for Wisconsin can be found on the web at wicci.wisc.edu/climate/index.html.

We experienced two unusually extreme precipitation events in parts of Wisconsin in August 2007 and June 2008. While these rain events caused much damage in many areas, many trout streams benefited from the groundwater recharge. I coincidentally began monitoring stream flow one month before the first flood in July 2007 in a number of Driftless Area streams in which we have set up trout monitoring stations to be surveyed on an annual basis. While some monitors were lost in the flooding, many survived and provided interesting and valuable data.

In Timber Coulee Creek, for example, water depth at the monitoring site increased from less than 2 ft. to briefly over 13 ft. during the August 2007 flood. Following this flash flood, the base flow had increased by about 12%. This base flow persisted to the following year and increased by another 12% following the June 2008 flood. These observations suggest that the extreme precipitation events were beneficial to groundwater recharge and input in the Timber Coulee watershed.

> *"The conservation of groundwater resources will play a critical role in protecting coldwater resources in Wisconsin in the face of a changing climate. Increases in precipitation in Wisconsin will likely benefit the recharge of groundwater, the extent to which will vary across watersheds, and may help buffer streams to the effects of warming...."*

This was not the case in all watersheds. Flooding also occurred in Mormon Coulee Creek in a nearby watershed (water level increased from 2 ft. to briefly over 17 ft. during the August 2007 flood) but base flow did not increase.

### Conserving groundwater

The conservation of groundwater resources will play a critical role in protecting coldwater resources in Wisconsin in the face of a changing climate. Increases in precipitation in Wisconsin will likely benefit the recharge of groundwater, the extent to which will vary across watersheds, and may help buffer streams to the effects of warming temperatures.

But we also need to be aware that should changes in climate bring drought conditions, the threat of warming air temperatures will be that much worse. Therefore, the protection of groundwater resources that support a coldwater environment in streams will be critical to the preservation of trout in Wisconsin in the face of our changing climate.

*(Matt Mitro is the Coldwater Fisheries Research Scientist for the WDNR. -Ed.)*



# Report lists ag chemicals present in WI groundwater

A 2008 report entitled "Agricultural Chemicals in Wisconsin Groundwater" (Agricultural Resource Management Publication 98) contains the most recent survey of the chemical impacts to Wisconsin's groundwater from the state's agriculture industry.

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The report is the result of a co-operative effort between three units of Wisconsin government:

- the WI Dept. of Agriculture, Trade and Consumer Protection (DATCP) was responsible for overall project management and laboratory analysis;
- the Bureau of Environmental & Occupational Health of the Wisconsin Department of Health and Family Services provided funding and supplemental water testing kits and will analyze information on water use by rural households; and
- the Wisconsin Field Office of the National Agricultural Statistics Service developed survey procedures, collected water use data, and summarized lab results.

Between January 2007 and June 2007, 398 private drinking water wells were sampled as part of a statewide survey of agricultural chemicals in WI groundwater.

Besides getting a current picture of ag chemicals in groundwater, the survey results could also be compared to the levels in earlier surveys conducted in 1994, 1996, and 2001.

Wells were selected using a stratified random sampling procedure and were used to represent Wisconsin groundwater accessible by private wells.

### Compounds tested for

Samples were analyzed for 32 compounds, including herbicides, herbicide metabolites, one insecticide, and nitrate-nitrogen.

Based on statistical analysis of the sample results, it was estimated that the proportion of wells in Wisconsin that contained a detectable level of a pesticide or pesticide metabolite was 33.5%.

Areas of the state with a higher intensity of agriculture generally had higher frequencies of detections of pesticides and nitrate-nitrogen.

The two most commonly detected pesticide compounds were the herbicide metabolites alachlor and metolachlor, which each had a proportion estimate of 21.6%.

The statewide estimate of the proportion of wells that contained atrazine total chlorinated residues (TCR) was 11.7%. The estimate of the proportion of wells that exceeded the 3 µg/l enforcement standard for TCR was 0.4%. Estimates of the mean detect concentrations for pesticides were generally less than 1.0 µg/l. The estimate of the proportion of wells that exceeded the 10 mg/l enforcement standard for nitrate-nitrogen was 9.0%.

### Changes over time

A time trend analysis was performed to determine whether the proportion estimates for atrazine, nitrate-nitrogen, alachlor, and metolachlor in private wells had changed between the 2001 survey and the 2007 survey.

The results of this analysis did not show any statistically significant changes for these compounds over this time period.

### About the chemicals cited in this report

**Alachlor** is marketed under the trade names Alanex, Bronco, Cannon, Crop Star, Intrro, Lariat, Lasso, Micro-Tech, and Partner. It mixes well with other herbicides, and is found in mixed formulations with atrazine and other chemicals to control annual grasses and broadleaf weeds in worn, soybeans, and peanuts.

**Atrazine** is used to stop pre- and post-emergence broadleaf and grassy weeds. Atrazine was banned in the European Union (EU) in 2004 because of its persistent groundwater contamination. It is said to be the most commonly used herbicide in the world.

**Metolachlor** is a general use pesticide sold under the trade names Bicep, CGA-24705, Dual, Pennant, and Pimagram. The compound may be used in formulations with other pesticides (often herbicides that control broad leaved weeds) including atrazine, cyanazine, and fluometuron. Metolachlor is moderately toxic to fish, including rainbow trout, carp, and bluegill.