

Proposed Regional Synthesis Report
Glacial Aquifer Planning Team

2/05/04

**Effects of deicing chemicals on ground water and surface-water quality in glaciated parts
of the United States**

Scope (NAWQA components / constituents): Urban land-use study wells, urban MAS wells, basic fixed sites, flowpath networks, and other long-term state water-quality networks. Analysis of major ion data, nutrient and VOC data may be used as ancillary data sets.

Study Units: CONN, HDSN, DELR, LINJ, LERI, NECB, UMIS, REDN, WMIC, WHMI, UIRB, EIWA, PUGT and COOK study units

Time period: 1992-2003

Land use(s): Urban and undeveloped

Is this an inter-regional proposal? Yes

Expected authors – Lead: John Mullaney (CONN), David Lorenz (UMIS)

Contributing: James Stark, James Fallon (UMIS)

Objectives

1. Describe concentrations of ions related to deicing chemicals (sodium, chloride, other ions) in urbanized shallow aquifers and in urban stream baseflow
2. Determine how concentrations in streams and ground water relate to secondary maximum contaminant levels, and aquatic criteria.
3. Relate concentrations to application rates, land use, hydrogeology and climatic factors.
4. Describe relations between sodium, chloride and other urban anthropogenic contaminants.
5. Determine if ion-exchange reactions are occurring that change water chemistry (ie. sodium exchange for calcium) by comparison with water type at reference sites.
6. Determine if ground-water discharge to streams is a major contributor of road deicing chemicals relative to the annual load.

Data interpretation approach & feasibility

Data interpretation would require the analysis of data from urban land use well networks as well as surface-water stations with no point-source wastewater discharges. Therefore, it will take some time to determine which data from NAWQA surface water and ground-water stations are most appropriate to fulfill the objectives. It is likely that a major part of the FY04 effort would be to organize the data set and begin interpretation.

The study of deicing chemicals is feasible because major ions have been analyzed in most NAWQA samples. Other associated anthropogenic water-quality constituents (nutrients, metals VOCs, etc). also would exist from NAWQA sampling.

Number of sites / components (e.g.: nutrients, pesticides):

There are about 380 ground-water sites from urban and forested land use well networks, and data are available from about 50 surface-water monitoring sites in urban and reference indicator networks.

Methods (standard? new?):

Regression analyses of chloride concentration and yield to hydrologic, climate, and land use variables.

Comparative statistics, for ground water and surface water data

Hydrograph separation needed to determine surface water samples collected during base flow

Ground water hydrograph separation, analysis of existing flow-path data and base flow load estimation. These techniques may require some development.

Some GIS interpretation of existing data layers will be necessary.

Data availability & processing:

Chemical concentration data, ground-water flowpath and ground-water age data and streamflow data are available in District NWIS databases, files and reports. Data from NAWQA compilations, and the data warehouse. Deicer, fertilizer, atmospheric deposition, land use, geology, soils data would need to be compiled from available data.

Staff availability: Mullaney and staff of Jim Stark will work on the project at .25 FTE during FY04, and at .5 FTE in FY05, and around .2 FTE in FY06.

Complexity: Moderate: There is considerable expertise required to integrate water-quality, hydrologic, and ancillary data at the regional level.

Risks / contingencies:

May have a limited number of surface water sites that are suitable. Established hydrograph separation methods are not appropriate in regulated basins, and streams with adequate temporal record may be a problem. Ground-water networks may not be nested in surface-water monitoring basins.

Other Program contacts: Dave Mueller, Wayne Lapham, and John Zogorski

Expected Outcome

We will produce a report or journal article on the regional findings. This report will describe the status of deicing chemicals in ground water in the different study units, the relation to land use and typical application rates, and the potential for ground-water loading to surface water-based on hydrogeologic factors. The report will describe the differences in ground-water water chemistry caused by application of deicing chemicals.

Why is this topic important to report on?

Chloride in ground water and surface water is a major water-quality issue facing the northern half of the United States and is frequently the contaminant of concern in impaired urban streams. The use of road salt has dramatically increased since the 1950's, and concentrations continue to increase in ground water and surface waters with increasing urbanization. (See fig. Below from Heisig 1999), and from Trench and Vecchia, (2002).

In drinking water, excessive chloride can degrade palatability and is often associated with sodium, which can cause hypertension. Additional concerns about chloride result from its conservative chemical nature. Chloride generally remains in water and is not removed by treatment processes. In the environment, aquatic habitats may be negatively affected by road salt constituents. Although Best-Management Practices can reduce the loading of NaCl to streams from runoff, these practices can increase loading to ground water. The effects of these chemicals discharging from ground water to streams are not well understood.

Concerns with chloride include:

- 1) general degradation of ground water and surface-water quality;
- 2) effects on aquatic habitat,
- 3) effects on drinking water supplies and human health:
 - a.) Degradation of public surface-water supplies through increasing urbanization of upstream watersheds
 - b.) Degradation of public and private ground-water supplies through application and storage of road salt in the contributing areas to these wells.
 - c.) Degradation of public and private water-supply infrastructure (plumbing) through increased corrosion that can occur with elevated chloride concentrations.
- 4.) Potential changes in ground-water and surface water chemistry, primarily ion-exchange reactions (primarily sorption of sodium, and release of base cations and trace metals) causing changes to water chemistry that may affect water supplies and sensitive resources such as wetland communities (Richburg and others 2001).

Why does this topic need to be addressed now? Why USGS? Why NAWQA? Why this region?

The effects of expansion of urban areas have received a significant amount of attention through terms like “Smart Growth, sustainable growth.” The effect of deicing chemicals on water quality and the aquatic environment is one of the most important issues facing northern glaciated regions with substantial urban growth. State environmental agencies and transportation departments are concerned about the potential environmental impacts of deicing compounds. Changes in sodium chloride can be tied to changes in biotic response, and NAWQA has more information on concentrations and loads of sodium chloride and other urban contaminants and on aquatic communities than any other agency.

The USGS and the NAWQA program have a unique capability to synthesize uniformly collected data over a large region in order to understand the National significance of this issue. This project is in line with the larger goals of the NAWQA program including water quality on a regional scale, relevant regional information to help protect drinking water and aquatic resources that take into consideration the interdependent nature of aquifers and river systems. This region has many similarities in climate, annual temperature, and the degree to which ground-water and surface-water resources are connected. These areas are also facing similar challenges in providing sustainable development. It is important to understand if there are differences in the way that deicing chemicals are appearing in the environment.

Who cares?

The New York City Department of Environmental Protection is interested in maintaining ground-water quality in the upland basins that serve the [NYC public water supply](#). The [USGS](#) has participated in investigations that have included analysis of chloride in base flow.

The state of Massachusetts is concerned with the proper disposal of snow accumulated from plowing operations to avoid contamination of water resources. The state of Massachusetts has a [long-standing program with the USGS](#) on issues relating to deicing compounds. The [Massachusetts District has also had a program with the Federal Highway Administration](#) to understand highway runoff issues.

In Connecticut, the [Norwalk River watershed initiative](#) is interested in reducing the effects of road salt on the Norwalk River, a long-term USGS station (District and NAWQA trend site).

In Rhode Island, the the Rhode Island Department of Transportation, and the Providence Water Supply Board have been concerned with sodium levels in the water-supply reservoirs for the Providence area. The [USGS](#) participated in a study of the effects of changing deicing chemicals from 1983-2000. Results of the study showed that sodium levels did not decrease following a change in the mixture applied to State roads. The authors concluded that private salt applications or residual sodium in soils were responsible for the lack of improvement.

[Minneapolis, Minnesota](#)—NAWQA findings for Shingle Creek and other urban streams near the greater Minneapolis metropolitan area brought to light what now appears to be a widespread chloride problem with significant implications regarding TMDL “course-of-actions.” Chemical and biology samples collected by USGS in Shingle and Nine Mile creeks and 13 other major streams in the metropolitan area indicated clear relations between chloride concentrations and impervious surfaces and snowmelt (which is highly suggestive of salt applications for road-deicing). The data, placed in context with other NAWQA samples in urban streams throughout the Nation, showed that both locally and nationwide, chloride concentrations significantly increase with increasing development. Prior to these USGS findings, the Shingle Creek Watershed Management Commission believed that chloride in Shingle Creek was a local, and solely a stockpile, issue. On the basis of USGS chloride results, the Commission now recommends a metropolitan-wide approach to assess current practices of road salt use and to explore alternatives to sodium chloride (such as calcium magnesium acetate, which is higher in cost, but has a slower activation rate). The improved assessment of chloride sources led to improved strategies needed to meet Minnesota standards.

The State of Ohio is concerned with the use of road salts, and has been actively [monitoring ground water quality](#) in Cooperation with the USGS for the effects of road salting.

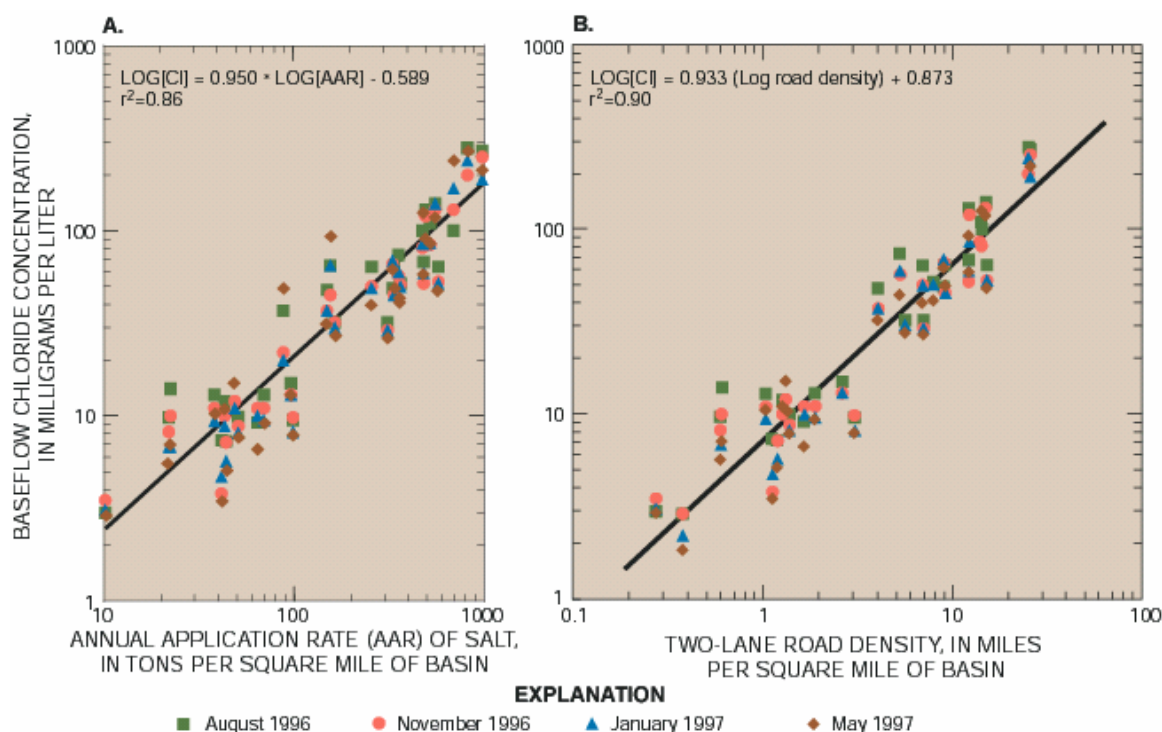
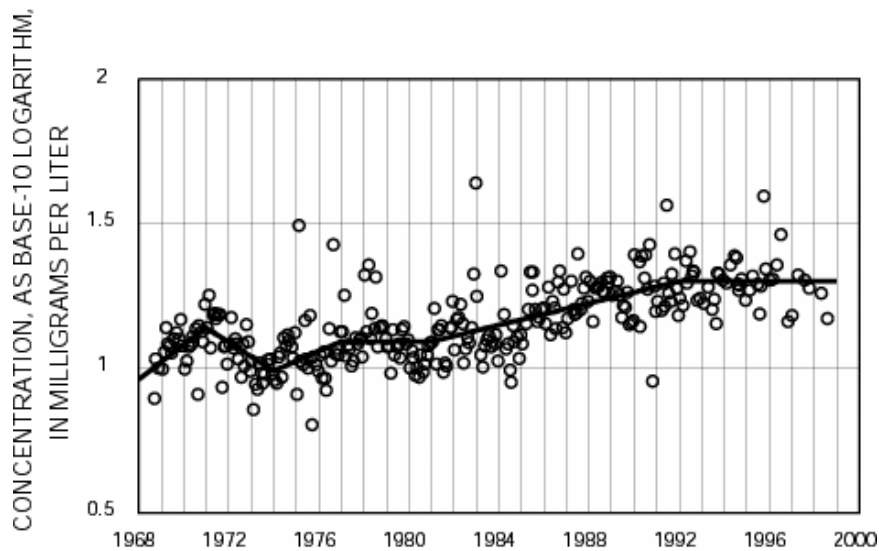


Figure 4.Relation of the concentration of chloride in baseflow in small streams in the Croton watershed in southeastern New York, August 1996 through May 1997, to: A. Annual road-salt application. B. Density of two-lane roads.



Trends in chloride concentration at the Saugatuck River near Redding Connecticut, 1968-98.

Selected References

Andrews, W. J., Fong, A. L., Harrod, L., and Dittes, M.E., 1998, Water-quality assessment of part of the Upper Mississippi River Basin, Minnesota and Wisconsin—Ground-water quality in an urban part of the Twin Cities Metropolitan Area, Minnesota, 1996: U. S. geological Survey Water-Resources Investigations Report 97-4248, 54p.

Heisig, P.M., 1999, [Effects of residential and agricultural land uses on the chemical quality of baseflow of small streams in the Croton watershed, southeastern New York](#), U.S. Geological Survey Water-Resources Investigations Report 99-4173, 15 p.

Richburg, J.A., Patterson, W.A., Lowenstein, F.L., Effects of road salt and phragmites australis invasion on the vegetation of a western Massachusetts calcareous lake-basin fen: Wetlands, v. 21 no. 2 p.247-255.

Trench, E.C.T., and Vecchia, A.V., 2002, Water-quality trend analysis and sampling design for streams in Connecticut, 1968-98