

**1. Introduction**
Urban roadways require the application of deicing agents to manage and maintain traffic conditions during periods of heavy snowfall and freezing conditions (Ramakrishna et al., 2003). Deicing agents are often applied in the form of sodium chloride (i.e., rock salt). Studies have shown that elevated levels of chloride in streams can be toxic to aquatic ecosystems (Corsi, 2002).

**3. Results**

3a. Correlation between electrical conductivity and chloride concentration

The success of this study depends upon having a high degree of correlation between frequently measured EC and infrequently measured chloride concentration. A comparison of EC measurements and chloride concentrations from surface water samples acquired over a three-year period is shown in Figure 4. This figure shows that there is an excellent correlation between EC and chloride concentration, suggesting that EC can be used as a reliable indicator of chloride contamination in surface water.

**3b. Temporal analysis of chloride concentrations**

Analysis of chloride data acquired in the last three years shows that some streams are more impacted by chloride than others (Figure 6). Streams with higher chloride concentrations tend to be in more urban areas or downstream of less-impacted areas. The severity of winter weather does not appear to have a significant impact on chloride concentrations in surface water.

**3c. Chloride concentrations in groundwater**

Electrical conductivity and chloride samples were acquired in two groundwater monitoring wells on the UWEC campus. Analysis has focused on the relationship between EC measurements in groundwater with those from nearby surface water. Well 1 is near the Little Niagara Creek, while Well 11 is near the Chippewa River. Data acquisition on the Chippewa River has been discontinued from the period because measurements were always very low and have not shown any correlation to chloride variations in Well 11. In contrast, the Little Niagara Creek has shown more variation in EC and indicates a positive relationship between chloride concentrations in groundwater and surface water. Figure 9 shows how EC measurements in surface water and groundwater change with time. Similar patterns are observed in both the streams and Well 1, but the response in Well 1 occurs slightly after that in the Little Niagara Stream, as some time is needed for the chloride to travel through the 11.8 km aquifer before entering the groundwater. At other times, the EC in Well 1 increases significantly faster than in the Little Niagara, the latter suggests that higher EC could be caused by non-chloride ions, or it could indicate that higher EC values have occurred in the stream, but were not captured by our sampling. The similarity in the Well 1 and Little Niagara data sets shows that road salting can have a significant impact on both groundwater and surface water quality.

**3d. Chloride concentrations and melting**

To determine whether high chloride concentrations were closely related to melting, data collected in the winters of 2013-2015 were compared to maximum temperature and the change in temperature (temperature gradient). For the temperature gradient, the maximum change in temperature was calculated over four 12-hour periods before the chloride measurement was acquired. Figure 7 shows that chloride concentrations were lowest in late November and early December, the period immediately following snowfall events and downstream of increased runoff, i.e., during warming periods when ambient air temperatures were above 0°C.

**2. Data Acquisition**
To determine the impact of road salting on selected streams in Eau Claire, WI, four tributaries of the Chippewa River and two groundwater monitoring wells were systematically monitored for chloride and electrical conductivity during the 2013-2015 winter seasons (Figure 1). Monitoring efforts were undertaken as part of the statewide Water Action Volunteers (WAV) program managed by the Wisconsin Department of Natural Resources (WDNR) and University of Wisconsin-Extension (UWEX). Monitoring was performed by measuring the electrical conductivity (EC) of the water (Figure 2); the EC could then be correlated to chloride concentration. Water samples were also collected at each sampling location once per winter season. Measurements of EC were performed at least twice a month from Oct. to March as part of a routine sampling schedule. Additional “triggered” monitoring was performed during instances of salt application (i.e., immediately following snowfall events) and downstream of increased runoff (i.e., during warming periods when ambient air temperatures were above 0°C).

**4. Conclusions**

The results of this study show that road salting has a significant impact on chloride concentrations in surface water and groundwater in the Eau Claire area. Higher chloride concentrations are observed during precipitation as well as during snowmelt if the temperature is between 2°C and 6°C, and gradual warming causes higher concentrations to be observed. Samples were also undertaken as part of the statewide Water Action Volunteers (WAV) program managed by the Wisconsin Department of Natural Resources (WDNR) and University of Wisconsin-Extension (UWEX). Monitoring was performed by measuring the electrical conductivity (EC) of the water (Figure 2); the EC could then be correlated to chloride concentration. Water samples were also collected at each sampling location once per winter season. Measurements of EC were performed at least twice a month from Oct. to March as part of a routine sampling schedule. Additional “triggered” monitoring was performed during instances of salt application (i.e., immediately following snowfall events) and downstream of increased runoff (i.e., during warming periods when ambient air temperatures were above 0°C).

**6. References**


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**Figure 3**: A strong linear correlation exists between EC and chloride.

**Figure 4**: Chloride concentrations at each sampling site with time. Circles represent measurements acquired as part of routine sampling, while triangles represent measurements acquired in response to a triggered event.

**Figure 5**: Surface sample locations

**Figure 6**: Chloride concentration as a function of location

**Figure 7**: Chloride concentrations as a function of air temperature for three streams.

**Figure 8**: Chloride concentrations as a function of air temperature gradient for three streams.

**Figure 9**: Similar patterns are observed in the Little Niagara, Well 1, and Well 11 with an expected lag period between the response in surface water and in groundwater.