Report No.:	WMPPT-2013-05-15	**Date:**	15 May 2013
To:	Grand River Water Management Plan Steering Committee		
From:	Claire Holeton, Water Quality Specialist, GRCA		
Subject:	Chloride concentrations in surface water		

REPORT:

Chloride is the ionic form of the element chlorine and is a common, naturally occurring chemical that can be found at elevated concentrations in aquatic environments as a result of human activity. Natural background concentrations of chloride in surface water are generally no more than a few milligrams per litre, with some local or regional instances of higher concentration (CCME 2011). High concentrations of chloride can cause water quality issues, such as aquatic habitat degradation and impairment of water uses, including raw drinking water supplies and agricultural irrigation. A common natural source of chloride is groundwater. Sources derived from human activities (road salts, water softeners, wastewater effluent, industry discharge and fertilizers) can lead to contamination of water bodies by high concentrations of chloride (OMOE 2003).

Although there is currently no water quality objective for chloride in Ontario, the Canadian guidelines for chloride set by the Canadian Council of Ministers of the Environment indicate increased risk of harm to aquatic life after long term exposure to concentrations above 120 mg/L (CCME 2011). The guidelines also indicate increased risk of harm to aquatic life after short term exposure to concentrations above 640 mg/L. Among the most sensitive organisms to chloride exposure are freshwater mussels, many of which are species at risk. The Grand River watershed supports populations of freshwater mussel species including the wavy-rayed lampmussel (*Lampsilis fasciola*) and has suitable habitat for the northern riffleshell mussel (*Epioblasma torulosa rangiana*). These species are designated as special concern and endangered, respectively (COSEWIC 2010a, COSEWIC 2010b) and have larval stages with a high sensitivity to chloride (CCME 2011). There are also Canadian guidelines for other water uses, such as agricultural irrigation and supply of drinking water, which set acceptable levels at comparable or less sensitive (higher) thresholds.

Chloride contamination is a common issue in urban and urbanizing areas and is closely associated with road density (due to de-icing activities) and population in areas with hard water (due to residential use of water softeners) (Stone et al. 2010; CCME 2011; Betts 2013). There is limited data available to provide a characterization of chloride conditions in the Grand River watershed, particularly in the winter and early spring when chloride can peak due to inputs from meltwater. Recent measurements (2005-2012) can be used to illustrate at a coarse level the areas in the watershed where chloride is more problematic, however since data is sparse and sampling often misses melt events, the true range of concentrations is likely higher. Seasonal chloride variations, shown in Figure 1 and described by Cooke and Loomer (2011), suggest that the concentration of chloride approaches and sometimes exceeds the Canadian guidelines for the protection of aquatic life in reaches downstream of some urban areas and major transportation routes. In the urban centre of the watershed during the summer and fall (April-November), the middle range of chloride concentrations (i.e. median value) is close to or over the guideline for long term conditions at a number of locations (Figure 1, left). During the winter/spring, peaks in concentration (shown as the 75^{th} percentile) are highest in samples from urban tributaries; concentrations in Schneider's Creek, which receives stormwater drainage from an urban area of Kitchener, exceed the guideline for short term concentrations (Figure 1, right). Peaks in concentrations in Laurel Creek, another urban tributary are also relatively high. Sampling of other urban tributaries that drain comparable landscape would likely show similar patterns.

In recent decades, there has been an increasing trend in concentrations, particularly downstream from urban locations (Cooke and Loomer 2011). An increase in chloride concentrations are seen in the reaches below many of the WWTPs (e.g. below Guelph, Figure 2), particularly in instances where the volume of discharge is large relative to the flow in the receiving watercourse. The increasing trend at sites above WWTPs (e.g. sites 1-3 on Figure 2) is largely a reflection of a recent increase in maximal concentrations during the winter/early spring season when salt used for de-icing is washed off hard surfaces with meltwater. Chloride from road salt applied in cold weather can also persist on the roadside soils or sediments of stormwater management ponds, and slowly leach out into surface water, causing elevated concentrations during the remainder of the year (Stone 2010; CCME 2011; Loomer and Cooke 2011). Discharge of groundwater contaminated by chloride may be an additional source of increased chloride in some reaches. Increasing chloride concentrations have also reported in groundwater in the central region of the watershed, and have been linked to inputs from salts used on roads and other paved areas (Bester et al. 2006).

Since chloride inputs typically increase with population growth and extent of urbanized areas, this issue is likely to worsen in the absence of management actions to control chloride inputs. Continuation of the increasing trend in chloride could result in significant stress on aquatic communities and water uses. To adequately assess the level of risk and track improvements in chloride in response to management actions, it is important that a strategic approach be applied to increase data collection in priority areas and undertake an evaluation that characterizes conditions at appropriate spatial and temporal scale.

Chloride is often very high in urban stormwater and can accumulate at the bottom of stormwater ponds (CCME 2011). Management of chloride is particularly difficult since it is a highly soluble and mobile ion, so it is difficult to trap and remove. Once it has entered the water, there are no major sinks or natural removal mechanisms to remediate high chloride concentrations. Consequently, most methods to manage impacts from high concentrations of chloride focus on limiting inputs through reduced use of chloride-containing substances (e.g. road salt, water softeners) or decreasing the likelihood of chloride release into the natural environment. For instance, Environment Canada has added road salt to the Priority Substance list of the Canadian Environment Protection Act in an effort to reduce impacts from the chloride present in road salt (EC & HC 2001).

There are number of programs currently active in the watershed that focus on reduction in salt use in de-icing activities, such as the Smart About Salt program and Snow and Ice Control for Parking-lots and Sidewalks (SICOPS) (Stone et al. 2010). There are also regional efforts to reduce salt use associated with water softeners that increase chloride loads in wastewater effluent: the Region of Waterloo partnered with Guelph for a study of the efficiency of various softeners, with the aim of educating residents, plumbers and retailers about choices which might reduce their salt (and water) footprint (Region of Waterloo 2012). These and other efforts to control chloride pollution are an essential component of a management strategy for the prevention of impacts from high chloride concentrations.

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Prepared by:

Claire Holeton
Water Quality Specialist

Sandra Cooke
Senior Water Quality Supervisor

Approved by:

Lorrie Minshall, P.Eng
WMP Project Manager

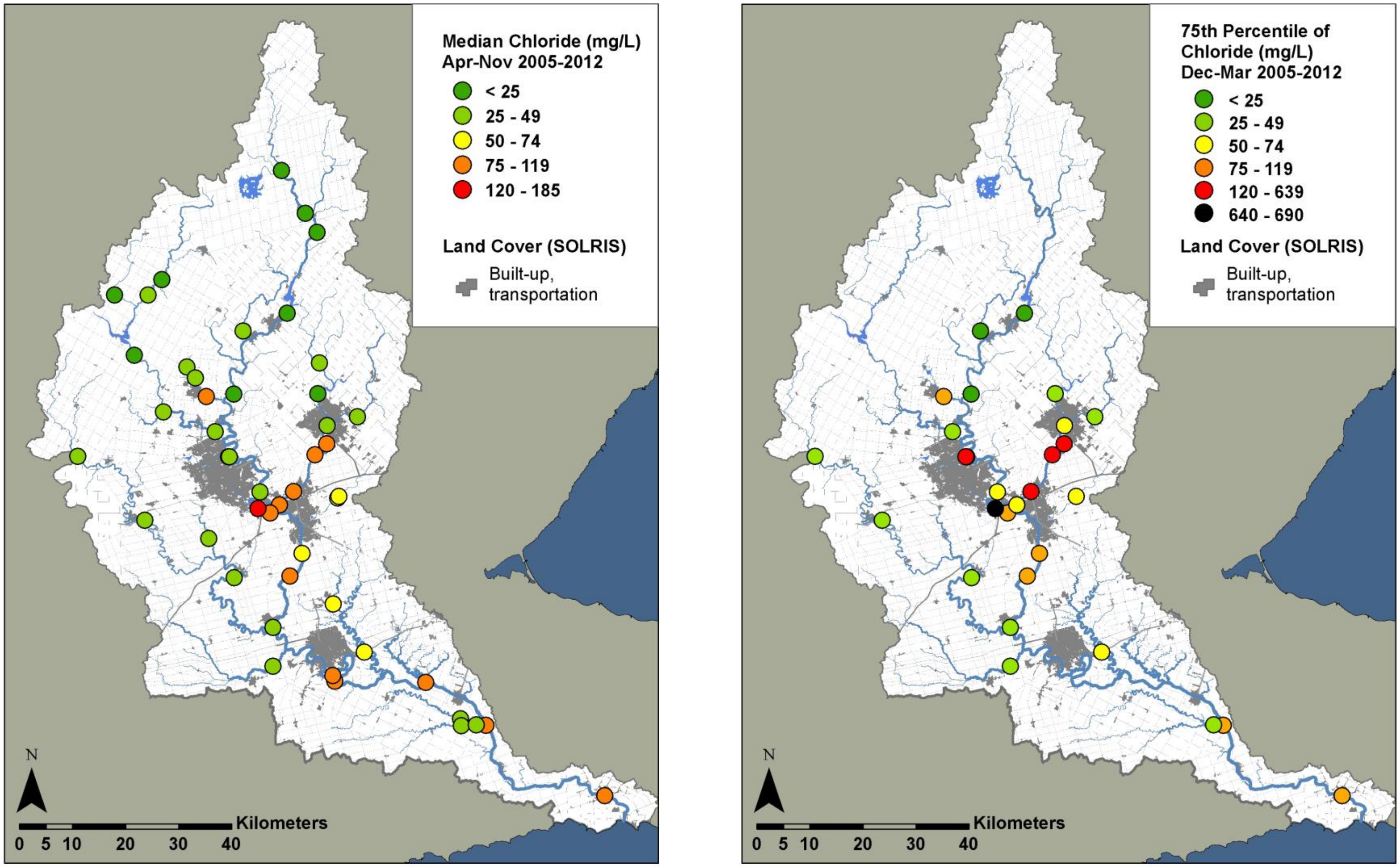
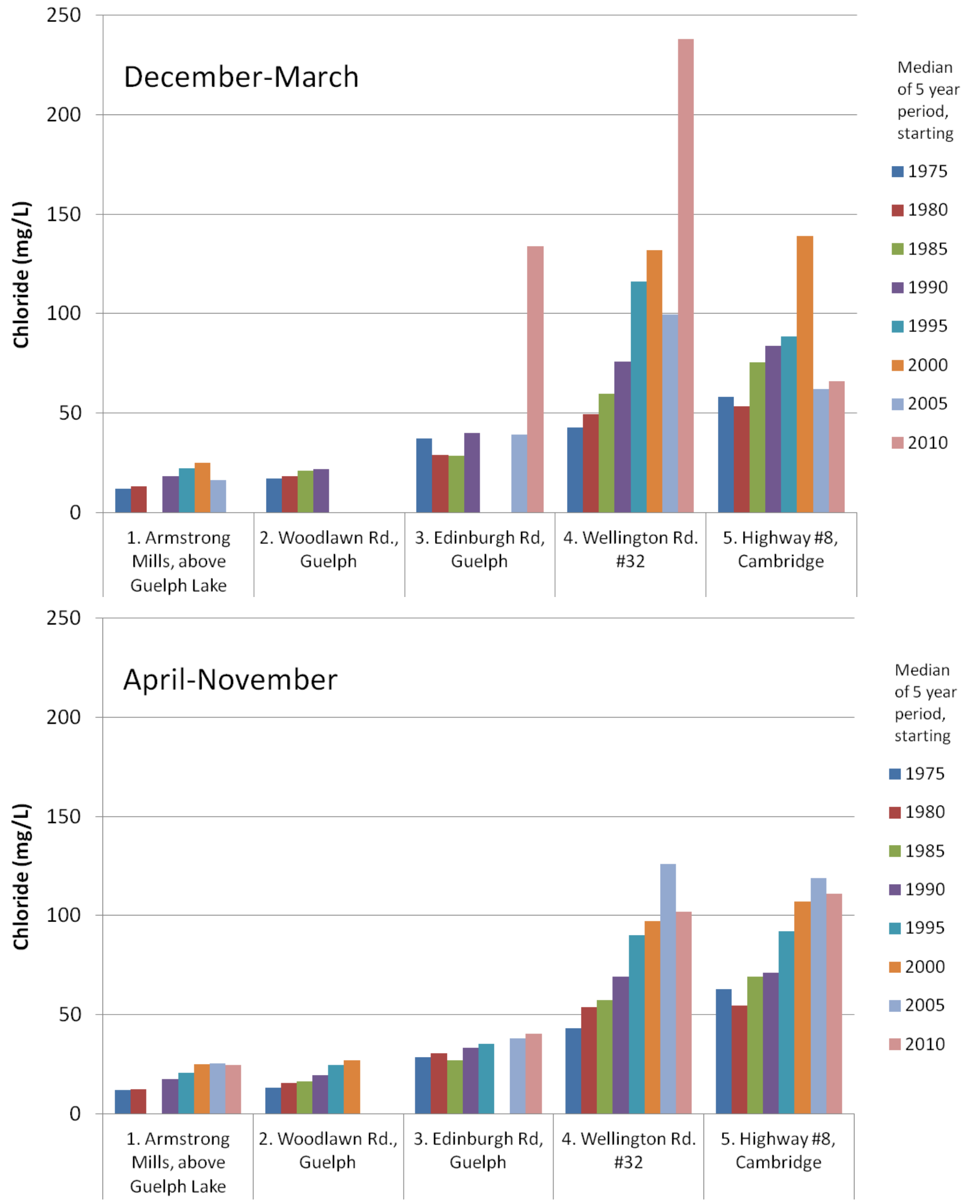


Figure 1. Variations in chloride conditions in Grand River watershed during the summer (left) and winter/spring (right). Chronically high chloride conditions during summer/fall are illustrated using the median value (April – November); peaks during winter/spring melt periods, are illustrated using the 75th percentile of concentrations (December – March). The Canadian guidelines for long and short term chloride concentrations are <120 mg/L and <640, respectively (CCME 2011).



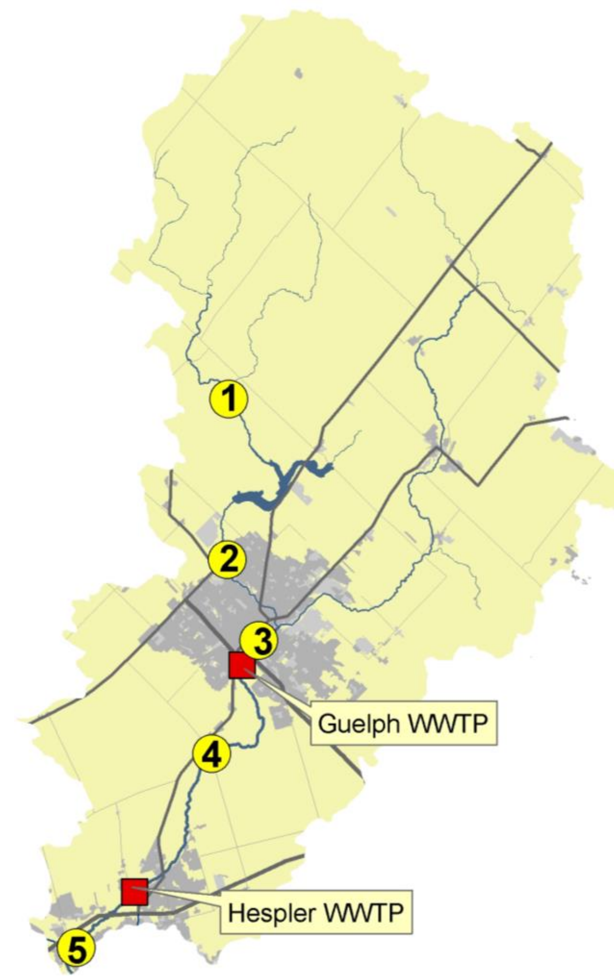


Figure 2. Long term trends in the seasonal medians of chloride concentration in the Speed River (1970-2012). Locations of sites in the Speed/Eramosa subwatershed are shown in relation to major roads and highways, urban areas (grey) and wastewater treatment plants (WWTPs; red squares).