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# Protection strategies for drinking groundwater sources in small Quebec municipalities

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**Abstract**

Awareness of groundwater protection has increased substantially in recent decades. In the Province of Quebec, Canada, the Groundwater Catchment Regulation (GWCR) was promulgated in 2002 to protect water quality in public wells. The goal of the present study was to document groundwater protection in the context of emerging regulations and identify factors explaining the propensity of municipalities applying protection strategies. Two types of information were used in this study: data from a questionnaire-based survey conducted among 665 municipalities in the Province of Quebec and complementary information gathered from various sources. Data from the survey revealed that fewer than half of the municipalities have been able to comply with the GWCR, mainly because of financial limitations. Also, close to half of the municipalities have either identified or are expecting land use conflicts to arise between protection areas required by the GWCR and other land usage, with agriculture being the main conflicting activity. Multivariate logistic regression models served to identify factors explaining the likelihood of municipalities to take groundwater protection measures. Those factors were municipality revenue, history of water contamination in distribution systems, land use near wellheads, location of municipalities within a provincial priority watershed and the importance of groundwater use in a region. Results of the study may prove helpful for government authorities in better understanding the groundwater protection issue and in implementing strategies that improve the ability of municipalities to protect groundwater.


*Keywords:* Groundwater; Sources; Protection; Regulations; Multivariate regression; Wellhead; Well; Drinking water

## 1. Introduction

It is estimated that 3% of the world's drinking water sources are located in the Province of Quebec, Canada (MDDEP, 2004a). Groundwater accounts for a large part of the water resources in Quebec. More than 20% of the population and over half of municipal water utilities use groundwater as their primary supply of drinking water (MDDEP, 2004a). However, drinking water sources can be contaminated by microbial or chemical contaminants potentially hazardous to human health (Environment Canada, 2004). In 2000, the Walkerton tragedy in Ontario confirmed such a statement when the contamination of the public water supply by the *Escherichia coli* bacteria caused the death of seven people and made more than 2300 others sick. Many factors contributed to the outbreak of the Walkerton events, among which was identified the lack of protective measures, in particular, given that manure was spread close to the location of the well (O'Connor, 2002).

One year after the Walkerton tragedy in Ontario, Quebec promulgated its regulation respecting the quality of drinking water (RQDW) (Government of Quebec, 2001) in which 77 water quality standards were updated. Henceforth, municipalities using surface water (i.e. lakes, rivers, etc.) or groundwater under the direct influence of surface water as a source of drinking water are required to filter and disinfect water in order to comply with new regulations. This will necessitate new municipal infrastructures and major financial investment, particularly for small municipalities.

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For several municipalities, the use of a groundwater source constitutes an interesting alternative to ensuring compliance with the RQDW. To a certain extent, groundwater is considered to be naturally protected from contamination (Komatina, 1994). As such, Quebec's RQDW standards are not as stringent for groundwater as they are for surface water. However, even if such natural protection exists, contaminants can still reach the aquifer (Chartrand et al., 2000; Levallois et al., 1998). High concentrations of nitrates in the groundwater of agricultural watersheds is a real issue (MDDEP, 2004b; Levallois and Landry, 2000). If consumed by infants, water with concentrations of nitrates exceeding 10 mg/L can cause methemoglobinemia (Almasri and Kaluarachchi, 2004), often referred to as "Blue Baby Syndrome". Moreover, once an aquifer has been contaminated, it is very hard to decontaminate it (Environment Canada, 2004).

Canadians have become more and more aware of the fact that threats to water quality and quantity can have a profound impact on their health, the environment and the economy (CCME, 2004). It has been demonstrated that the most effective way to manage drinking water systems is to implement a multi-barrier approach consisting of an integrated system of procedures, processes and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health. Source water protection is the first barrier identified in the multi-barrier approach and is particularly relevant, considering that prevention of contamination at the source has been identified to be more cost-efficient than the treatment of contaminated water (US EPA, 2000), not to mention that such environmental protection also benefits from social acceptance.

In 1996 in the United States, the Environmental Protection Agency (US EPA) amended its Safe Drinking Water Act (SDWA), requiring states to develop Source Water Assessment Programs (SWAPs). SWAPs incorporate the multi-barrier approach and target groundwater protection, requiring states to delineate protection areas, identify potential sources of contamination within protection areas, determine groundwater susceptibility to contamination and establish procedures, including the establishment of technical and citizens advisory committees, to encourage public participation in the development of the protection program for wellhead areas and SWAPs (US EPA, 1997).

Inspired by the American experience, the Government of Quebec adopted the Groundwater Catchment Regulation (GWCR) (Government of Quebec, 2002), aimed at the protection of groundwater sources for the drinking water supply. Municipalities must delineate wellheads[1] catchment areas, and identify bacteriological and virological protection areas based on groundwater times of transport of 200 days for bacteria and 550 days for viruses. In addition, they must determine groundwater vulnerability using the DRASTIC method (Aller et al., 1985) and conduct an inventory of land use or activities likely to modify groundwater microbiological quality. There are particular clauses in the regulation directed at agriculture. The presence of livestock farms, as well as the spreading or stocking of manure, are prohibited inside bacteriological areas if groundwater has been determined vulnerable. In a context of small rural municipalities where agriculture is a primary activity, these clauses may have a considerable impact on land use planning, since an overlapping of protection areas and agricultural lands can result in land use conflicts.

Very little information is available on how municipalities are dealing with groundwater protection and, specifically, the new GWCR requirements. Referring to Ontario's case, De Loe et al. (2002) and De Loe and Kreutzwiser (2003) suggest that a community's capacity to achieve its groundwater protection objectives is shaped by technical, financial, institutional, political and social considerations.

This paper aims at documenting the situation of small municipalities with respect to wellhead protection before and after the promulgation of the GWCR in Quebec. The study identifies present or potential conflicts between wellhead protection areas and other land uses within the territory and identifies and discusses factors that favor the propensity of municipalities establishing wellhead protection strategies.

## 2. Methodology

### 2.1. Study area

The study area encompassed seven administrative regions of Quebec, namely Chaudière-Appalaches, Montérégie, Lanaudière, Bas-Saint-Laurent, Capitale Nationale, Estrie and Centre du Québec (Fig. 1a). In most municipalities in these regions, agriculture is an important economic activity. Fig. 1b illustrates municipalities having more than 25% of their municipal territory allocated to agriculture. For several municipalities, more manure is produced than the crop uptake capacity on the municipal scale. Those municipalities are facing a situation termed *Excess of manure* by the Environment Ministry of Quebec (Fig. 1c). The Environment Ministry of Quebec has identified and studied seven watersheds with an excess of manure and found higher concentrations of nitrates and higher bacteriological contamination frequencies in these watersheds than in other watersheds with low or moderate agriculture land use (MDDEP, 2004b). The seven watersheds are also part of the region under study in this project.

### 2.2. Questionnaire-based survey

A questionnaire-based survey sent by mail was conducted in the study area on 665 municipalities. The

[1]Private wellheads are not targeted by the GWCR and were not investigated in the present study; therefore the term "wellhead" refers only to municipal wellheads.