

DRAFT



Lest the Well Run Dry

Municipal Approaches to Groundwater Quantity Monitoring and Management

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Acknowledgements

The H₂O Chelsea project would like to thank the Walter & Duncan Gordon Foundation for providing the funding for this manual and other components of our Groundwater Quantity Monitoring Kits.



H₂O Chelsea would not exist without the committed efforts of its partners: the **Municipality of Chelsea**, the **Institute of the Environment** at the University of Ottawa, **Action Chelsea for the Respect of the Environment (ACRE)** and the hundreds of Chelsea residents who have shown great support for the project since its inception in 2003.



H₂O Chelsea is a community-based water research and monitoring program developed collaboratively by the Municipality of Chelsea, the University of Ottawa's Institute of the Environment and Action Chelsea for the Respect of the Environment (ACRE). Our goal is to develop a better understanding of ground and surface water resources in Chelsea that will inform municipal planning and management decisions. The project has developed groundwater, lake and stream monitoring programs that are available for transfer to interested communities. Please visit our website for details: www.h2ochelsea.ca

The Municipality of Chelsea was awarded a 2006 Federation of Canadian Municipalities *Sustainable Community Award* for their participation in the H₂O Chelsea project.



Forward

The majority of homes in our municipality are built on bedrock of the pre-Cambrian shield. Because of the exorbitant cost of developing municipal water and wastewater infrastructure in bedrock regions, we rely entirely on domestic wells for our water requirements.

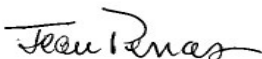
With the aim of learning what can be done to protect our ‘most precious resource’, Chelsea commissioned a groundwater study (Golder Report, 1990) in the late 1980s that mapped out areas of the municipality that might be sensitive to contamination and water scarcity. The report included recommendations such as minimum lot sizes of one and two acres in order to decrease well and septic system densities, construction requirements for new drilled wells in the Municipality, as well as several recommendations to protect groundwater quality. Chelsea implemented these recommendations and went on to develop other water protection initiatives including: a municipal septic tank emptying program, a wetlands protection by-law and legislation banning the cosmetic use of pesticides. In 2003, we partnered with the University of Ottawa and Action Chelsea for the Respect of the Environment to create the H₂O Chelsea project, the details of which are contained in this manual.

Community support for these initiatives and municipal involvement in groundwater management has been overwhelming—despite provincial laws which dictate that residential water-well management is the private responsibility of individual property owners. We believe that a resource as important as groundwater demands a community-wide approach to ensure its sustainability. I encourage all municipal leaders of groundwater-dependent communities to read this manual to learn about practical monitoring and legislation options which exist that can help your community protect its groundwater resources in the long term.

I would like to thank the Walter and Duncan Gordon Foundation for funding the production of this manual and many of the other resources that make up the H₂O Chelsea Groundwater Quantity Monitoring Program. This generous support will help us share our knowledge and experiences with other municipalities across the country.

We look forward to hearing from you in order to discuss how you can establish similar programs in your community.

Regards,



Jean Perras
Mayor
Municipality of Chelsea

Abstract

Groundwater is used extensively throughout the world for residential, agricultural and industrial water needs. Despite its extensive use, groundwater quantity and availability is very expensive to test. H₂O Chelsea developed the Groundwater Quantity Monitoring Programs to help close the gaps in knowledge of this water source. This guide details municipal approaches to understanding and managing groundwater quantity.

This *Municipal Approaches to Groundwater Quantity Management* manual lists the various water quantity monitoring tools developed by H₂O Chelsea as well as key regulatory and educational approaches to groundwater management developed by the Municipality of Chelsea and various municipal governments across North America. These tools and approaches were designed to educate people about groundwater quantity as well as monitor, understand and protect aquifers. Public education (part one) is the first step to promoting sustainable water use. The Water Quantity Questionnaire (part two) and Census (part three) developed by H₂O Chelsea help obtain baseline information about groundwater quality and quantity. The Static Level Program (part 4) offers an inexpensive way of monitoring short and long term water levels of local aquifers. Designed as alternatives to expensive groundwater modeling, these tools and resources incur minimal costs to a municipality, yet are effective to increase general awareness and understanding about groundwater resources. Finally, several municipal planning concepts and legislative recourses to help protect groundwater quantity are discussed (part 5).

This manual has been prepared with the specific goal of facilitating the transfer of our water resource monitoring and education programs to other communities. Please consult our website (www.h2ochelsea.ca) for more information.

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Introduction

Many regions in Canada rely on groundwater as their main source for residential, agricultural and industrial water requirements. Therefore, protection of this resource not only makes environmental sense, it also makes financial sense. When groundwater can no longer sustain a community, the municipal government, although not necessarily legally required to do so (varies according to jurisdiction), will be politically and morally compelled to supply residents with an alternative solution (installing deep communal wells, installing water and wastewater infrastructure etc.). These solutions can be very costly.

According to the Quebec Groundwater Catchment Regulation, groundwater catchment by one user should not have negative impacts on other users or surface water bodies. Every new well must be authorized by local or regional authority; and it must be built following location, construction and performance specifications. However, once the structure has been built, its management is the responsibility of the owner. Therefore, in most jurisdictions, groundwater management is a private responsibility accorded to the individual owners of waterwells. This legal arrangement results in an unmanaged system whereby there is little understanding or control of a community's groundwater resources.

The aim of this manual is to encourage municipal governments to assume a role in the management of their aquifers, despite the fact that they are not bound to do so by federal or provincial regulations. The availability of an adequate supply of groundwater cannot be left to chance.

This *Municipal Approaches to Groundwater Quantity Management* manual lists various tools developed by H₂O Chelsea, the Municipality of Chelsea and other municipalities across North America that were designed to educate people about groundwater quantity as well as monitor, understand, and protect aquifers. The initiatives were designed based on the *precautionary principle*: reduce groundwater consumption in order to avoid water shortages in the future, even in the absence of scientific data indicating that shortages are imminent. Designed as alternatives to expensive groundwater modeling (pump tests etc.), these tools and resources incur minimal costs to a municipality, yet are effective to increase public awareness of groundwater resources and the opportunities that exist for conservation.

It should be noted that each community has different needs regarding water quantity research, education, and protection. This guide provides a wide variety of options—ranging from community education to intensive groundwater quantity testing methods. It is important that each municipality gear its groundwater quantity project to match the financial, human resources, and hydrogeological realities of their community.

Finally, we would like to remind the reader that the groundwater resources mentioned in this document have been designed or compiled by H₂O Chelsea specifically for transfer to other communities. Please consult our website to learn more and to access these resources online.

Groundwater Primer

Groundwater exists almost everywhere underground, be it in the porosity of an unconsolidated medium such as sand or gravel or in the fractures of massive impermeable rocks. Much of the earth's freshwater is stored underground. Although groundwater exists everywhere underground, some areas contain more water than others. An *aquifer* is an underground formation of permeable rock or loose material which has the ability to store and transmit water.

The sizes of these aquifers vary, but from a water production standpoint, larger more productive aquifers which have high transmission (transmissivity) and storage (storativity) capacities are the most valuable. If a geologic formation can store but not transmit water, it has little value for production. The opposite is also true. Aquifer storage and transmission capacities are calculated from the results of aquifer tests (e.g. pump tests). Although these tests are very informative about the geologic formation, these tests are also very expensive to conduct. Furthermore, in some cases such as heterogeneous geologic formations where flow is anisotropic (differs according to the direction of measurement.), results of pump tests only characterize aquifer parameters in the vicinity of the well. This is why wells where demand is relatively low (such as domestic wells) are drilled without extensive aquifer testing.

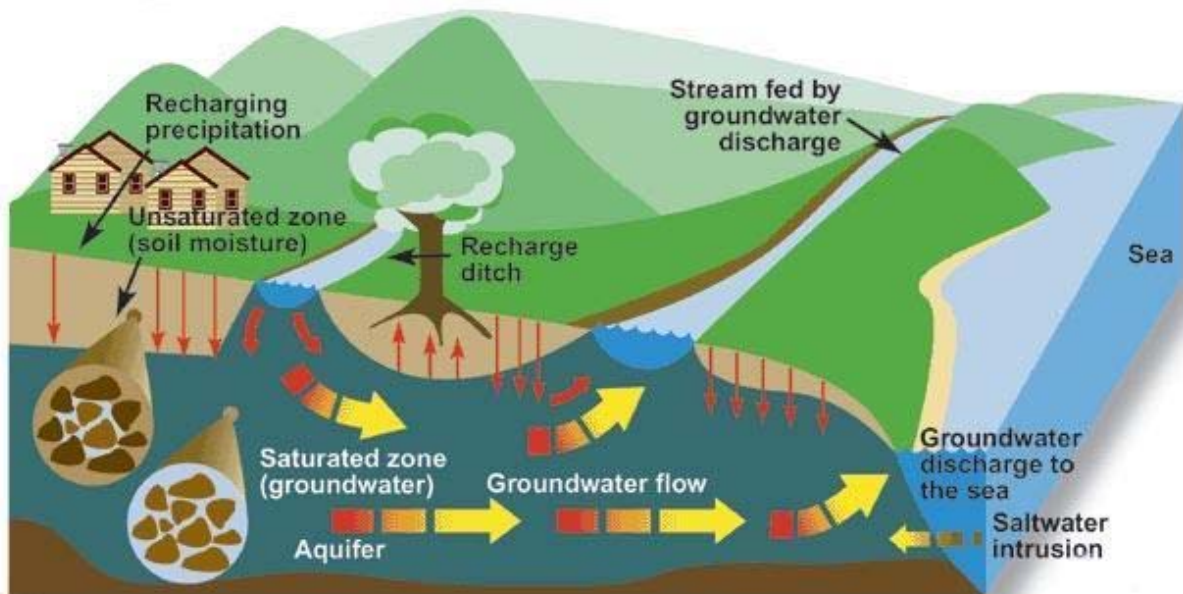


Figure 1. Illustration of groundwater flow through an aquifer

Reference: Groundwater Flows, <http://www.ec.gc.ca/water/images/manage/effic/a6f5e.htm>, Environment Canada, 2006.

The ground is considered to be made up of two main classes of substances:

- ✓ Permeable materials which are sufficiently porous to store water and allow it to move freely.
- ✓ Impermeable materials include: materials with low porosities which do not allow for high water storage or transmission and; materials such as clay which have high porosities, but where water is bound to soil particles.

Hydrogeologists generally classify aquifers into two categories: porous medium and fractured rock. In porous media (unconsolidated) aquifers, water moves between particles. These aquifers are often more productive than fractured rock aquifers. In fractured rock (consolidated) aquifers, water fills the joints and cracks of fractured rock massifs, which are otherwise solid and impermeable. Classification of aquifers goes further to divide these two broad categories as confined, unconfined or semi-confined aquifers.

Groundwater flow depends on surface and bedrock relief flowing down the gradient of the surface or bedrock. Flow also depends on water pressure, moving from higher water pressure to lower water pressure.

In Canada, approximately 30 percent of the population relies on groundwater for domestic uses; approximately two-thirds of these users are in rural settings.¹ Groundwater is used for municipal, domestic, agriculture (including livestock), and various industrial uses. Many of these purposes can also increase the vulnerability of aquifers to contamination. Some confined aquifers are completely isolated bodies of water; water removed from these aquifers is not replenished. The water level goes down until the aquifer could theoretically dry out. However, aquifers are rarely isolated bodies of water. Groundwater and surface water are interconnected in recharging or discharging the aquifer. Overdrawing an aquifer causes the static water level to drop, and can cause shallow wells to dry out, and in extreme cases, lead to ground subsidence². Groundwater quantity monitoring can help determine the rate of sustainable yield³.

It has long been known that seasonal and natural climate changes affect water levels in aquifers. Scientists predict that, as a part of the hydrologic cycle, groundwater resources will be affected by climate change by:

- ✓ changing recharge patterns due to shifts in climate and precipitation,
- ✓ changing in surface water distribution which will affect surface water-groundwater interaction,
- ✓ increased water demand for consumption, crop production, industrial processes, and electricity.

¹ Environment Canada, Greenlane, Groundwater

http://www.ec.gc.ca/water/en/nature/grdwtr/e_gdwtr.htm

Rutherford, S. (2004) *Groundwater Use In Canada* West Coast Environmental Law

<http://www.wcel.org/wcelpub/2004/14184.pdf>

² Ground subsidence refers to a lowering of the land-surface elevation from changes that take place underground; where water pressure is reduced from over pumping the aquifer

³ Sustainable yield refers to water use which preserves the water table level; water released from storage (discharge) must be equal or less than water returning to the aquifer (recharge)

Various types of aquifers respond differently to surface stress. Shallow aquifers respond more quickly to surface stresses than deeper aquifers. These deeper aquifers are often shown to be more resistant to change. However, as water scarcity becomes an issue, exploitation of these aquifers becomes greater. Due to the uncertainties associated with the impact of climate change on groundwater, understanding the resource has become even more important.

Why monitor groundwater quantity?

Water is necessary for all life on earth. When groundwater is the main source of water to residents for agricultural or industrial purposes, water shortages will necessarily have a devastating impact on the community. By planning proactively, monitoring groundwater quantity and reacting to monitoring results, municipal planners can decrease the odds of water shortages, and find solutions before water shortages become problematic. This document details concrete actions that can be taken to protect water quantity and even favor groundwater replenishment.

Municipal responsibility

Many Canadian cities have opted to develop city-wide water distribution systems. Water for these systems may originate from surface water or groundwater. With large scale water distribution systems it is easier for the city's or municipality's administration to monitor water quality and quantity supplied to residents. The use of domestic water wells shifts the responsibility of water from the municipality to individual residents. Guidelines have been developed both provincially and federally for water quality testing^{4,5} as well as recommendations for protecting groundwater quantity for domestic well owners; however, these are not regulated. Therefore, municipalities can choose their degree of implication in groundwater management.

There is a critical need for better understanding of water resources in municipalities where there is no municipal control of groundwater use, especially where groundwater quantity is an issue threatening to impact on daily requirements of citizens and limit the growth of the community. Arguably, due to growing populations, and a finite amount of fresh water on our planet, most municipalities/cities fall into this category. In the event of inadequate water quantity due to low aquifer yield or decreased storage, municipalities will necessarily feel compelled to develop alternative sources of water for their citizens. Seen in this light, groundwater protection becomes crucial not only for ecological reasons, but for economic reasons as well. More and more, our society is beginning to appreciate that the environment and the economy are inextricably linked. Governments would be wise to incorporate this principle into their decision making processes.

⁴ Health Canada, Environmental & Workplace Health, Guidelines for Canadian Drinking water Quality http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/doc_sup-appui/index_e.html (2006-04-10)

⁵ Développement durable, Environnement et parcs Québec, *The Quality of my Well Water* <http://www.mddep.gouv.qc.ca/eau/potable/depliant/index-en.htm> (2002)

History of H₂O Chelsea

Chelsea relies exclusively on groundwater. The geography of the community—largely low-density housing built directly on the Precambrian Shield bedrock of the Gatineau Hills—precludes any chance of an economically viable municipal water or sewage system being developed. Groundwater quantity is an issue which is threatening to limit growth; ensuring adequate water resources for residents has become an administrative imperative.

The municipality of Chelsea has focused on the protection of groundwater quality and quantity since the late 1980's. As a precaution to protect groundwater in Chelsea, the municipality has adopted several laws: a by-law concerning pesticides⁶, which regulates the use of pesticides on its territory to protect the health of its citizens and the environment; a by-law regulating zoning in the municipality of Chelsea to protect wetlands⁷, which establishes setbacks and other standards governing any work performed in the vicinity of wetland areas; and a regulation imposing new construction requirements for wells built in the municipality through permits and certifications⁸. Also, the development policy in the 2005-2010 Urban Plan, sets a minimum lot size for housing development (4000m²) which allows for greater spacing between domestic wells and septic systems. These initiatives all help protect water sources and the ecological integrity of the municipal landscape. The Municipality also developed Comprehensive Development Programmes (CDP)⁹ to ensure that development or reconstruction occurring in the municipality would respect the cultural and ecological integrity (including groundwater) of the region. The CDP is discussed in greater details in section 5 of this document.

In addition to these planning tools, the Municipality of Chelsea established a watershed committee to brainstorm opportunities to promote the sustainable development of the municipality as it relates to protecting the ecological integrity of the watershed. This committee included residents of the municipality (including a professor from the University of Ottawa's Institute of the Environment), as well as members of ACRE (Action Chelsea for the Respect of the Environment), an active environmental group in Chelsea, and Chelsea municipal councillors. This committee recommended the development of the H₂O Chelsea program to oversee watershed management issues, including groundwater quantity monitoring and management.

A University of Ottawa master's student was hired to develop a detailed water quantity and quality program proposal¹⁰. The objective was to ensure that any eventual program could be operated mainly by volunteers in conjunction with resources provided by its three partners (the Municipality of Chelsea, the Institute of the Environment, and ACRE).

⁶ By-law text is available online on the municipality's website at <http://www.chelsea.ca/english/by-laws/PESTICIDES%20REG-e.pdf>

⁷ By-law text is available online on the municipality's website at <http://www.chelsea.ca/english/by-laws/559-02-terres-humides-521-99.pdf> (available in French only)

⁸ By-law No. 639-05 respecting Permits and Certificates http://www.chelsea.ca/english/639-05%20Permis_et_certificats_%20Anglais%20V1.pdf

⁹ By-law No 640-05 respecting Comprehensive Development Programmes <http://www.chelsea.ca/english/PAE%202005%20FINAL-e.pdf>

¹⁰ Program plan is available online on the H₂O Chelsea website at <http://www.acrechelsea.qc.ca/docs/WaterMonitoring.pdf>

H₂O Chelsea embarked on its first sampling season in the spring of 2003 and has since become a recognized leader in the realm of community-based water resource research.

H₂O Chelsea education and monitoring initiatives

1 Community education

The H₂O Chelsea project includes various programs which depend on the active participation of community members. Education resources were developed and distributed to Chelsea residents and business owners to increase awareness of local water resources, encourage community stewardship and recruit volunteers for our research and monitoring programs.

The following is a brief description of some of the education tools; more information can be obtained from the H₂O Chelsea Community Education webpage¹¹.

Community education Knowledge is key...

What?

Reaching out to residents to increase awareness on groundwater quantity issues in the community

How?

- *Water kits*
- *Water curriculum in schools*
- *Lecture series*
- *Presentation of results*
- *Website*

1.1 Water kits

Thanks to funding provided by the **Fonds d'action québécois pour le développement durable**, Chelsea produced 'Water Kits' that were sent to every business and household in Chelsea in May 2005. The kits contain a Chelsea-specific well and septic maintenance booklet, a pamphlet describing the aim of the project, a fridge magnet, and existing government literature that effectively conveys best management practices (BMP) for households that rely on wells and septic systems. Key themes include: ways to limit water use, 'septic-safe' cleaning products, and septic system maintenance.

Many of these documents are available on our website¹², ready to be adopted and modified by other communities. Key documents created by outside organizations, that we refer to on our website, include the Canadian Mortgage and Housing Corporation's (CMHC) *Household Guide to Water Efficiency*, which discusses the importance of water and methods for water conservation in a household. This guide can be purchased from the CHMC website¹³. Environment Canada has

¹¹ H2O Chelsea, Community Education

http://www.h2ochelsea.ca/community_education.htm

¹² Community Education Resources

www.h2ochelsea.ca/adopt_programs.htm

¹³ Canadian Mortgage and Housing Corporation, (2000) *Household Guide to water Efficiency*

<http://www.cmhc-schl.gc.ca/en/inpr/su/waco/index.cfm> (June 2006)

developed a set of comprehensive pamphlets for water conservation in and around the home. A printer-ready CD-R is available free of charge to municipalities and interest groups wanting to print a large quantity of one or more of the brochures for use in their own water efficiency program. Please see the Environment Canada website¹⁴ for more details. Many water conservation posters and bookmarks are available in English language versions (i.e. no French language version) on American websites¹⁵.

1.2 Water conservation curriculum for elementary schools

The idea of a water-themed interdisciplinary curriculum (science, history, geography etc.) was first developed by teachers at the Chelsea Elementary Public School and has been operating successfully for several years. The project involves the collaborative work of teachers, students and parent volunteers in grades five and six. Students research and develop their own water-themed play (including costumes and sets), and organize a presentation to parents and community members.

H₂O Chelsea is fine-tuning this water-themed curriculum in order to transfer it to educators in other communities. The curriculum package is available on the H₂O Chelsea website¹⁶.

1.3 Lecture series

One of H₂O Chelsea's three partners, Action Chelsea for the Respect of the Environment (ACRE)¹⁷, has organized several water-themed lectures that provide residents with scientific and practical hands-on information from local and visiting experts. Hosting a lecture series or information sessions can be as simple as contacting a nearby university or private company which is involved in groundwater monitoring or research. Professionals are often pleased to share their knowledge, explain their research, and spread interest in their field with others. Many lecturers are willing to offer their suggestions on how to maximize the effectiveness of your community's research programs.

1.4 Annual Report

H₂O Chelsea prepares an annual report detailing that year's water monitoring results. The report is prepared by University of Ottawa professors and recent doctoral graduates. The aim is to write

¹⁴ Environment Canada, Wise Use of Water Brochures

http://www.ec.gc.ca/water/en/info/pubs/brochure/e_broch.htm (Last updated: 2005-11-16)

¹⁵ The Groundwater Foundation, Groundwater Catalogue (see sections Community Education Activities and the Recycled Store)

<http://gallery.bcentral.com/Gallery/ProductListing.aspx?GID=5044929&Dept=327595> (English products only)

The Water System Council, Public Education, WSC Posters

<http://www.watersystemscouncil.org/education/posters.cfm> (English products only)

¹⁶ H₂O, The Amazing Study of Water, school curriculum guide

http://www.h2ochelsea.ca/Curriculum/curriculum_intro.htm

¹⁷ Action Chelsea for the Respect of the Environment (ACRE), Home page

<http://acrechelsea.gc.ca/> (2003)

the report so as to ensure that it is scientifically descriptive, yet at the same time accessible to the average reader (i.e. local residents with little scientific background). As Chelsea is a bilingual community, the report is available in French and English language versions.

Electronic copies of our research reports are made available through the project website¹⁸ while printed copies can be accessed at the public library.

1.5 Presentations of sampling results

Each year, a public presentation (bilingual) is organized to explain our research and monitoring results to the community. Public presentations are ideally made by a respected member of the science community who participates in your project, and who has the ability to explain complex scientific concepts in layman's terms. We organize our presentations to take place several weeks after the annual report is made available.

Not only do the presentations inform residents about research results, they are an important way of keeping volunteers enthusiastic about the project. It is important that volunteers be made aware of the positive outcomes, whether big or small, that stem from their work. Equally important, the presentations provide an opportunity to highlight the efforts of your volunteers and to recruit new ones.

1.6 Information booths at local events

H₂O Chelsea recognizes the importance of maintaining a public presence in the community and has been consistently present at the municipality's local events. Our information booths provide project literature and pamphlets and posters on water conservation and well maintenance. The booths are supervised by informed volunteers who can assist others in learning more about the project and ways to get involved.

We have participated in the following events:

- ✓ Earth Day celebrations
- ✓ United Nations World Water Day
- ✓ Community bazaars, carnivals and concerts

1.7 News updates in municipal and local newspapers and E-newsletters

The initiatives undertaken by H₂O Chelsea are numerous and constantly changing. Keeping residents up to date on activities is important. Printing articles that highlight the project's success stories in local newspapers or in the project's electronic newsletter keeps our initiatives on

¹⁸ Annual Reports

http://www.h2ochelsea.ca/proj_results.htm

people's minds. You can visit the *Latest News*¹⁹ section of H₂O Chelsea's homepage, or sign-up²⁰ for Chelsea's *free e-newsletter* to get updates regarding upcoming H₂O Chelsea lectures, presentations of results, news stories, and local events.

Bilingual templates of letters, e-mails, and newspaper articles developed by H₂O Chelsea are available on our website²¹. We encourage you to tailor these resources to your project's communication requirements.

2 Water questionnaire

In 2003, H₂O Chelsea sent a water questionnaire to every household and business in the municipality. The questions related to groundwater quantity and quality and were designed to collect baseline information that would assist H₂O Chelsea in developing relevant water research, monitoring and education activities. The feedback from the 600 responses (one quarter of the homes in Chelsea) from the 2003 Questionnaire helped inform our research priorities.

Perhaps the most important information gathered by the questionnaire relates to well-water shortages. The questionnaire asked residents to indicate the date and frequency of any water shortages they had experienced in the last three years. This allowed our researchers to create maps of reported water shortages in the community, providing a visual picture with which to assess if there were any spatial and/or temporal trends. Figure 2 illustrates the mapping of water shortage responses from the 2004 Questionnaire. Interpretation of these maps led our researchers to focus on four neighborhoods of Chelsea that had reported an above average number of shortages (compared to the rest of the community).

Water Questionnaire

A tool to determine research priorities in your community

What?

Asking residents to answer a short questionnaire on water quantity and quality regarding their residential well can help municipal planners understand the community's water source.

Why?

Responses from residents will assist you in creating monitoring and education programs that are geared towards the specific needs and interests of your community.

Ultimately, the H₂O Chelsea Water Questionnaire inspired us to develop our Static Level Program (see section 4 for details), and the H₂O Chelsea Water Census in 2005 (see section 3 of this report) in order to gain a better understanding of the water shortages that were reported. Please see the relevant sections of the report for further details.

¹⁹ H₂O Chelsea, Latest News Section

<http://www.h2ochelsea.ca/Introduction.htm>

²⁰ Keep up-to-date on H₂O Chelsea's ongoing events and workshops, email h2o@chelsea.ca with "subscribe" in the subject line.

http://www.h2ochelsea.ca/news_service.htm

²¹ Education and Communication Resources

http://www.h2ochelsea.ca/adopt_programs.htm

Water quality issues are also addressed by the Water Questionnaire. Groundwater and surface water quality monitoring are another important part of the H₂O Chelsea project that are not discussed in this water quantity report. Details of our water quality initiatives are available on our website.

Equally important, the questionnaire also played a critical role in informing Chelsea residents about the H₂O Chelsea project, its various programs, as well as current volunteer opportunities. We recommend that communities implement the Water Questionnaire (modified to suit your information needs) as a first step in developing your community-based water research initiative.

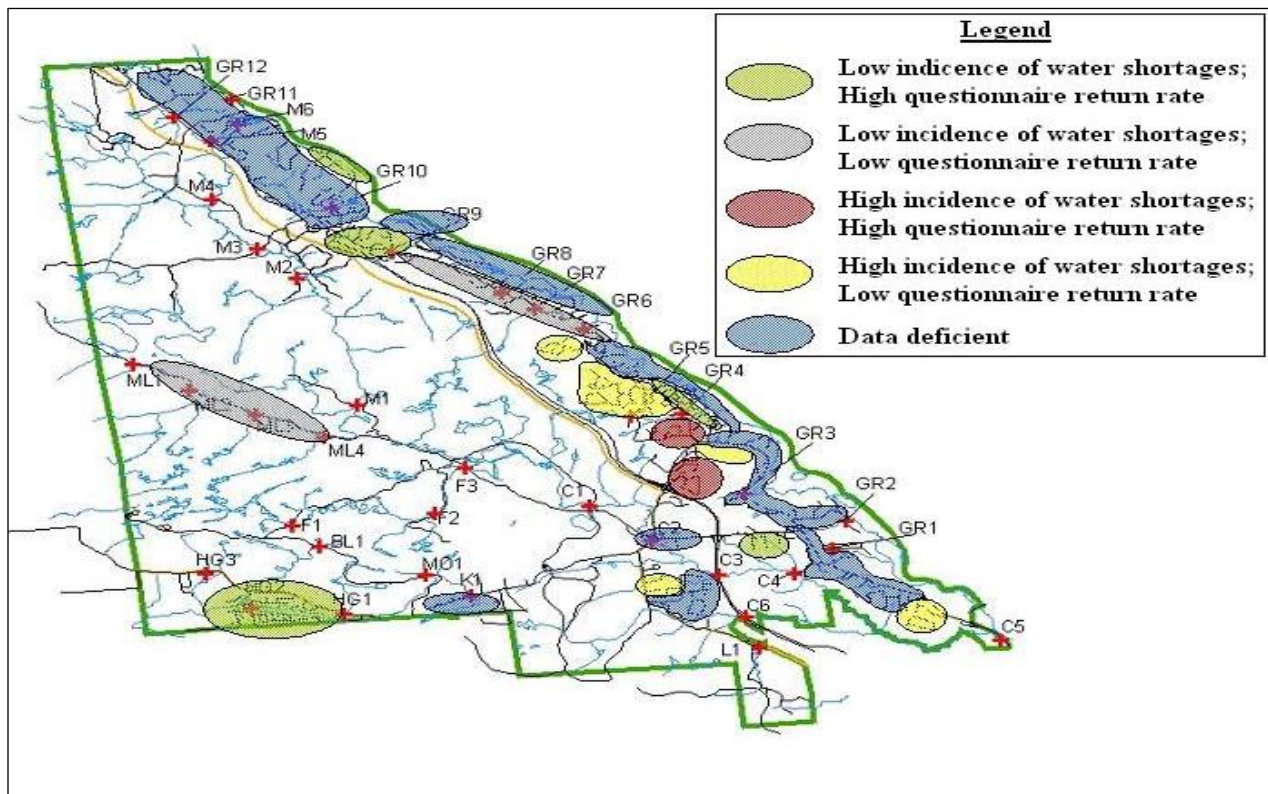


Figure 2. Reported Water Shortages from the 2003 Water Questionnaire.

Implementation

The H₂O Chelsea Water Questionnaire is short and quick to fill out. Residents are encouraged to complete it annually to ensure that H₂O Chelsea always has the most up to date information. There are two methods to complete the questionnaire:

1. An online form version of the water questionnaire is available on the municipal and project websites
2. A hard copy of the questionnaire can be mailed to residents or included in the municipal newsletter

H₂O Chelsea asks residents to complete their Water Questionnaire in the late fall (immediately after the late-summer drawdown period when water shortages are most likely to occur).

Want to learn more?

A copy of the 2004 H₂O Chelsea Water Questionnaire is available on the Municipality of Chelsea's website²².

The results of our 2003 and 2004 Water Questionnaire research are discussed in our *H₂O Chelsea Year 2 (2004): Summary of Water Monitoring Results*²³ report.

Please see the *H₂O Chelsea Water Questionnaire Implementation* manual²⁴ on our website for more information and tips on how to implement this monitoring tool in your community.

3 Water Census

Following up on the responses of the Water Questionnaire, H₂O Chelsea developed a Water Census²⁵ to acquire more detailed information about water shortages and water usage in the community. The 12 pages of questions were specifically designed to shed light on the following items:

- ✓ How often do residents of Chelsea experience water shortages? When do these shortages occur and for how long do they last?
- ✓ Are some areas of the municipality more prone to water shortages than others, perhaps indicating areas with limited or over-exploited groundwater resources?
- ✓ Are there certain water uses (e.g. watering gardens, swimming pools) or technical aspects of wells (e.g. depth, construction material) which increase the likelihood of experiencing a water shortage?
- ✓ Does the rate of household water-use impact on the likelihood of experiencing a well-water shortage?
- ✓ Would residents be interested in implementing water-use reduction strategies to minimize water shortages in their neighbourhood?

²² H₂O Chelsea Questionnaire 2005

http://chelsea.ca/english/environment/h2o_chelsea.asp

²³ Stow, N. Findlay, S. (2004) *H₂O Chelsea Year 2 (2004): Summary of Water Monitoring Results*.

<http://www.h2ochelsea.ca/PDFs/H20%20Chelsea%20year%20%20report-%20Jan%202026.pdf>

²⁴ H₂O Chelsea, Water Questionnaire Manual

www.h2ochelsea.ca/adopt_programs.htm

²⁵ Water Census

<http://www.h2ochelsea.ca/PDFs/Water%20survey%202005.pdf>

The results of the Water Census identify neighbourhoods that are vulnerable to water shortages and point to opportunities to minimize the incidences of these shortages. Mapping of the data can involve many strategies (see Figure 3). For example, water-shortage locations may be

overlayed on maps detailing other physical characteristics such as elevation and geological formations, in order to identify physical characteristics which may yield higher rates of water shortages. This information may be of use to municipal planners when developing land use plans.

The census also probed the community to see what type of municipal involvement in groundwater management they would support (e.g. would residents in shortage-prone neighbourhoods support a by-law regulating lawn watering during periods of drought?). This tallying of support from residents is important as municipal councils are naturally weary to implement a by-law/policy that may result in protest from an unknown number of citizens.

Implementation

In Chelsea, the Water Census was mailed out to all residents and businesses in November 2005 (soon after the late-summer drawdown period when water shortages are most likely). This time was chosen in order to ensure that residents would remember the details of any water shortages. Over 800 households returned the survey, out of a total of 2400 possible respondents.

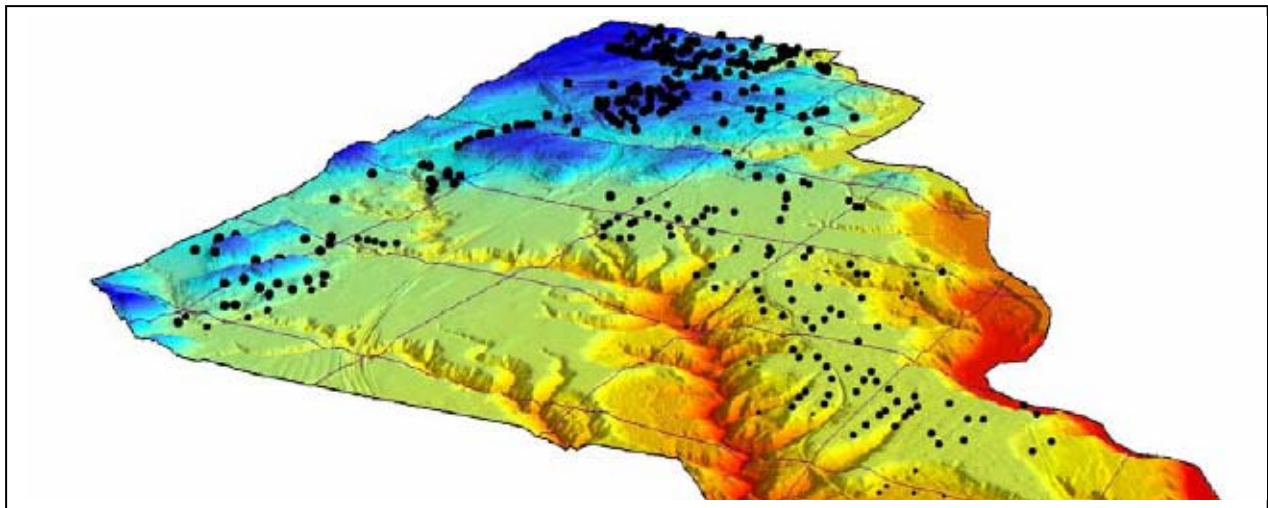


Figure 3. Water Shortages in the Water Census Target Area reported in the 2005 H₂O Chelsea Water Census

Water census

What are the causes of well-water shortages?

What?

A 12 page census asking specific questions related to groundwater consumption and well-water shortages

Why?

To seek more detailed information than is collected by the shorter water questionnaire. Of prime importance:

- ✓ *Are well water shortages random incidents or are some the result of lowering water tables?*
- ✓ *Does the rate of household water-use impact on the likelihood of experiencing a well water shortage?*

Our priority was to solicit responses in the specific regions of the municipality (target areas) that had reported a higher incidence of water shortages in past Water Questionnaires. Phone calls and house visits were conducted in these target areas in order to encourage residents to complete the census. In the non-target areas of the municipality, residents were encouraged to participate by way of a bulk-mail letter and an update in the municipal newsletter.

We encourage communities to collaborate with groundwater and survey design specialists to modify the Water Census to suit your community's research needs, analyse the data and make a presentation of the results (including recommendations) to the municipal council.

The H₂O Chelsea Water Census will soon be available as an online form²⁶. Cost restrictions and response rate objectives will impact on the choice of delivery method selected by each community (hard copy vs. online form).

Want to learn more?

A copy of the Water Census is available on the H₂O Chelsea website²⁷.

The *2005 Water Census Report*²⁸ detailing the analysis strategies and results of our November 2005 Water Census will be available on our project's website in late 2006.

Please see the *H₂O Chelsea Water Census Implementation* manual²⁹ on our website for further information and tips on how to implement this monitoring tool in your community.

4 Static Level

The static water level in a well is the height of water in the well when the aquifer reaches equilibrium (when the pump has not been used for an extended period of time and the water level returns to its natural level). By monitoring the static level of wells throughout the year, you can detect fluctuations in groundwater levels in local aquifers (Figure 4). By tracking the water levels over a longer period of time (multiple years), you can determine whether the water tables in your community are rising, falling, or staying at a constant level. A pattern of lowering water tables may be an indication that groundwater is being overdrawn (groundwater is not being used sustainably).

²⁶ Water Census Online Form
www.h2ochelsea.ca/adopt_programs.htm

²⁷ H₂O Chelsea Website
<http://h2ochelsea.ca/>

²⁸ Water Census Report
www.h2ochelsea.ca/proj_results.htm

²⁹ H₂O Chelsea, Water Census Manual
www.h2ochelsea.ca/adopt_programs.htm

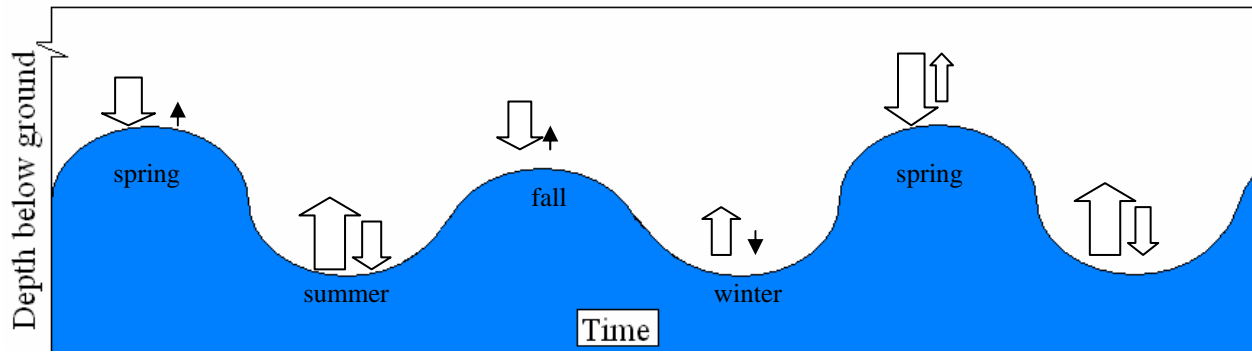


Figure 4. Illustration of the oscillatory behavior of static water level throughout the year

Once annual and long term trends are identified and confirmed, municipal planners should work with residents and the municipal council to decide if any corrective actions are advisable (please see Section 5 of this report: *Municipal Planning Concepts and Regulations to Protect Water Quantity* for some ideas regarding corrective and preventative measures to protect groundwater quantity). Some questions that may arise due to water data collected from the static level program:

- ✓ If water tables are lowering in a certain neighbourhood, should regulations be created to limit the number of new houses that can be developed there in the future?
- ✓ Should regulatory tools such as lawn watering by-laws be developed for certain regions with lowering water tables?

Please note that because it takes years of static water level monitoring to accurately determine long-term changes in an aquifer's water level (Figure 5) we encourage communities to practice precaution and to implement sustainable development policies before any water quantity problems arise.

The H₂O Chelsea Static Level Program is made up of two components: the Intensive Static Program and the Volunteer Static Program.

4.1 Intensive Static Program

The Intensive Static Program was developed to monitor well-water levels (static level) in neighbourhoods which reported a greater incidence (above the municipal average) of water

Static Level Monitoring

Are the water tables in your community rising, falling, or staying at the same level?

What?

Residents and/or project employees measure the static water level in local wells using inexpensive equipment.

Why?

Long term measurements of the static water level of the aquifers feeding your community can help you infer trends in groundwater levels, thus, helping you identify and protect areas where water levels may be decreasing.

shortages in the 2004 Water Questionnaire. Over 70 households in two neighbourhoods of Chelsea participated in this program providing excellent coverage for the small study areas. The Intensive Static Program required the hiring of a summer student to ensure that the wells involved in the study were guaranteed to be monitored monthly.

4.2 Volunteer Static Program

The Volunteer Static Program has the same goals as the Intensive Static Program but differs slightly in that:

1. residents volunteer to measure the static level of their own wells, and
2. the program involves monitoring throughout the municipality, not solely in neighbourhoods that reported a higher incidence of water shortages in the Water Questionnaire.

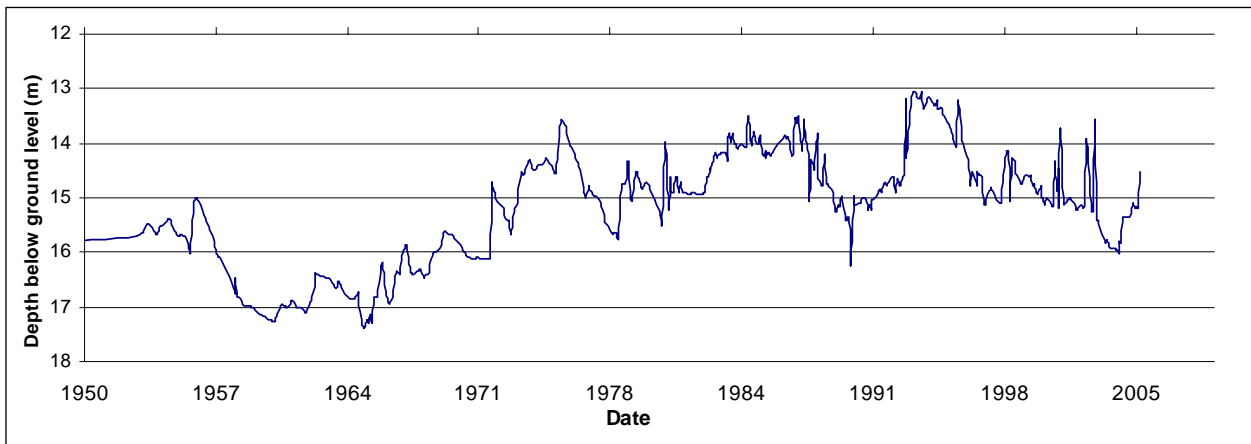


Figure 5. Hydrograph of well TR-009, Trempealeau County, Wisconsin.

Source Data: Hydrograph of Well TR-0009, <http://wi.water.usgs.gov/public/gw/HISTORICAL/TR-0009.html>, U.S. Geological Survey, Wisconsin Water Science Center, 2006

Implementation

In early spring, residents are asked to volunteer for the static level program. The volunteers receive training regarding the use of the monitoring equipment, data sheets and protocols. Participants measure the static level of their well once a month and input their results directly to the H₂O Chelsea database through an online form.

We encourage communities to collaborate with groundwater specialists to develop your Static Level Program (density of sampling wells, frequency of testing etc.) to suit your community's hydrogeological characteristics (aquifer type).

Want to learn more?

The Static Level Program data sheet and monitoring protocols are available on the H₂O Chelsea website³⁰.

The results of our 2004 Static Program are available in our *H₂O Chelsea Year 2 (2004)* report³¹.

Please see the *H₂O Chelsea Static Level Implementation* manual³² on our website for more information and tips on how to implement the program in your community.

5 Municipal planning concepts and regulations to protect water quantity

The groundwater monitoring tools discussed above were designed to give municipal planners affordable information about the aquifers in their community. This water quantity data should be carefully interpreted and used to inform municipal decision making that may affect the community's water resources. Municipal actions that can be taken to protect water quantity range from the creation of municipal by-laws and planning tools, to providing water-conservation recommendations to home and business owners.

Precautionary Principle

Municipalities need not wait several years while they conduct extensive studies before deciding to take actions to protect their groundwater resources. The precautionary principle states that it is best to act preventatively, even in the absence of supporting data.

This section of the report will discuss various options aimed at protecting water quantity that have been implemented in various communities in Canada and the United States. Note that planners can implement varying degrees of stringency, tailored to suit the needs of their community. Further, legal jurisdiction varies in each Canadian Province and Territory. Ensure that any planning tool you seek to develop is legally feasible in your area.

³⁰ Static Level Tool Kit

www.h2ochelsea.ca/adopt_programs.htm

³¹ Stow, N. Findlay, S. (2004) *H₂O Chelsea Year 2 (2004): Summary of Water Monitoring Results*

<http://www.h2ochelsea.ca/PDFs/H2O%20Chelsea%20year%202%20report-%20Jan%2026.pdf>

³² H₂O Chelsea, Static Level Manual

www.h2ochelsea.ca/adopt_programs

5.1 *Municipal planning tools*

5.1.1 **Planning for growth**

In growing communities, forward planning can ensure that the overall ecological integrity of the region be preserved. When essential resources are protected and distributed to all users; structural development occurs in a sustainable manner. Planning for growth in groundwater-dependant communities involves creating regulations to ensure that future developments will not negatively impact existing groundwater users.

An important component of forward planning is growth control. Reducing the number of properties developed under one contract slows development of the area. Therefore, if water quantity becomes an issue after the first developments, future requests can be considered in light of possible water deficiencies. At present, the responsibility of proving that water sources are sufficient to proceed with a project is the responsibility of the developer.

The document *Groundwater and its role in Comprehensive Planning*³³, produced by the Wisconsin Groundwater Coordinating Council, details why and how to adapt municipal planning to the groundwater quality and quantity needs of a community.

5.1.2 **Zoning**

In Chelsea, the objective of the zoning by-laws is to “foster desirable evolution of establishments and projects within the community by promoting the quality of life”³⁴. Adapting zoning to conserve groundwater quantity can help ensure that this objective is respected.

Groundwater conservation areas

In the past, municipal zoning was developed mostly to separate land uses to maintain harmonious development of residential housing and business opportunities. Differentiation of lands usually did not consider the ecological integrity of the landscape. However, reviewing present municipal zoning to protect key natural areas, including areas which favor groundwater recharge, may be beneficial to the municipality. Changing municipal zoning is difficult in developed areas; establishing groundwater conservation areas is mostly recommended as planning option for undeveloped lands. In Chelsea, conservation areas are protected by the creation and protection of buffer zones and no-construction/no-intervention zones.

The Massachusetts Department of Environmental Protection developed a model groundwater protection district bylaw/ordinance³⁵ as part of its drinking water program, to be adopted by

³³ *Groundwater and its role in Comprehensive Planning*, Wisconsin Groundwater Coordinating Council <http://dnr.wi.gov/org/water/dwg/gw/pubs/SmartGrowth1.pdf> (July, 2002)

³⁴ Municipality of Chelsea, Zoning Bylaw No. 636-05 <http://www.chelsea.ca/english/Zonage%202005%20Final-e.pdf>

³⁵ Model Groundwater Protection District Bylaw or Ordinance (text revised 2005) <http://www.mass.gov/dep/water/modgwpd.doc>

regions within that state. The main purpose of this regulation is to “promote the health, safety, and general welfare of the community by ensuring an adequate quality and quantity of drinking water for the residents, institutions, and businesses.” The by-law/ordinance requires that the township delineate groundwater protection districts, and then describes permitted and prohibited land uses on these areas. Note that this legislative tool is used to promote health of the entire system, in both groundwater quality and quantity.

Large lot zoning

Controlling lot sizes is another way to protect groundwater quantity. By increasing lot sizes, you decrease the density of groundwater wells. In Chelsea, lot sizes are a minimum of 1 acre for most residential lots; residential lots in aquifer protection zones have a 2 acre minimum. These lot size requirements, including the demarcation of the aquifer protection zones, were recommendations provided by a comprehensive water resource report prepared by Golder and Associates in 1990³⁶ for the Municipality of Chelsea. Note that large lot zoning to protect water quantity should be weighted against controlling sprawl. Details regarding Chelsea’s lot size specifications are included Municipality of Chelsea’s Master Plan, available on the municipality’s website³⁷.

5.1.3 Special Permitting

Instead of prohibiting an activity in certain areas (such as would be proposed in a zoning by-law) new construction in the municipality is reviewed on a case-by-case basis to assess its possible impact on groundwater quantity. Therefore, new structures are reviewed in light of their specific water requirements.

In Chelsea, the Comprehensive Development Programmes³⁸ (CDP) has been developed to allow municipal planners to assess each request on a case-by-case basis to oversee development in the areas covered by the CDP. This tool permits a unique development of sensitive parts of the municipality, without requiring any overarching modification to town planning. The CDP was developed in accordance with Quebec law (*Loi sur l'aménagement et l'urbanisme*³⁹ [LRQ., c.A-19.1], articles 84, paragraph 7 and 145.9 to 145.14). This planning tool ensures that the natural environment (including groundwater quantity, quality and replenishment) and the rural image of the village can be preserved while permitting appropriate development and land uses. In Chelsea, the CDP was purposely written ambiguously. This ensures that municipal planners may establish unique requirements for a property that is to be developed, in order to achieve the intended environmental standards deemed important for the property in question (e.g. increasing the buffer zone around wetlands beyond that which is set out in the municipal wetland by-law). Regulations vary in each province and territory; please review your provincial requirements to assess the applicability of the development of a CDP for your area.

³⁶ Golder report – insert ref.

³⁷ By-law No 635-05, Municipality of Chelsea Master Plan
http://www.chelsea.ca/english/635-05%20PU_Anglais.pdf

³⁸ By-law No 640-05 respecting Comprehensive Development Programmes
<http://www.chelsea.ca/english/PAE%202005%20FINAL-e.pdf>

³⁹ http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/A_19_1/A19_1.html
(last update 01/04/2006)

5.1.4 Municipal restrictions on land use

Once areas of natural value (such as wetlands, wooded areas, and other key groundwater recharge zones) have been identified in the area, the municipality may choose to ensure their protection with the following tools. The options listed below are given in order of increasing restrictiveness.

Restriction of use

By restricting the uses of land, planners prevent development that threatens the protection of resources, without the municipality having to own the parcel of land. For example, Chelsea has developed a wetland bylaw⁴⁰ which establishes setbacks and other standards governing any work performed in the vicinity of wetland areas to ensure their protection. Wetlands are important habitats for many species, but these areas are often also groundwater recharge zones. These areas filter water as it infiltrates into the ground. In Chelsea, a no-construction regulation applies, as well as a 15m (cadastre lots) or 30m (not cadastre lots) buffer zones around wetlands are required.

Regulatory takings

Regulatory takings are very similar to restrictions of use. In a regulatory taking, restrictions put on land uses are so strict (e.g. restricting the ability of the owner to erect any structures, or prohibitions on alteration of natural landscape, etc.) the government's regulations have effectively taken their property without the government needing to actually own the land in question. Regulatory takings also include the imposition of new regulations and restrictions on activities on developed lands (whereas restriction of use only applies when the land is undeveloped). In many cases, although the owner has full rights on the land, he or she is unable to use it as he or she initially intended. Although compensation is not required in regulatory takings, it is often considered as a viable alternative to diminish personal loss, and is strongly recommended. The legality of regulatory takings is questionable, and depends on the reasons for limitations on development. This tool should be used with great caution.

Land purchasing and compensated expropriation

Land purchasing or compensated expropriation can also be considered (although it is less common) to protect sensitive areas. In this scenario, the municipality buys back a parcel of land deemed important to protect natural resources. While this can have significant public benefits, these are often attained at the cost of the property owner or the municipal purse.

For example, a discussion paper produced by the Regional District of Nanaimo⁴¹, British Columbia, in regards to watershed and groundwater protection for drinking water, highlights that protection of source water is a priority for the future of drinking water management. In the scope of this study, residents indicated in a community feedback report⁴² that sensitive lands in

⁴⁰ By-law No 521-99, By-law wetlands (available in French only)
<http://www.chelsea.ca/english/by-laws/559-02-terres-humides-521-99.pdf>

⁴¹ Regional District of Nanaimo, Drinking Water Protection Action Plan
<http://www.rdn.bc.ca/cms/wpattachments/wpID421atID717.pdf> (October 26, 2004)

⁴² Regional District of Nanaimo, Feedback Report - Drinking Water Quality Protect Discussion Paper
<http://www.rdn.bc.ca/cms/wpattachments/wpID421atID642.pdf> (April 30, 2004)

watersheds and groundwater recharge areas should be acquired through purchase, negotiation or expropriation.

In Canada, there are several examples of land donations or purchasing for the protection of a valuable resource such as water. For example, a groundwater and well head protection study⁴³ for the Town of Kapuskasing, Ontario and nearby municipalities showed that expropriation was a valid strategy for groundwater protection.

5.1.5 Impervious cover thresholds and natural landscapes

Limiting paved areas within the municipality allows for better infiltration of surface water, allowing greater aquifer replenishment. For example, gravel roads and parking lots decrease surface runoff compared to using cement or asphalt. Also, decreasing the width of paved side streets and adding a gravel shoulder allows for better driving conditions, while favoring water infiltration. A study done at the University of Delaware (2000) for a watershed management conference discusses the role of impervious cover as a watershed-based zoning tool⁴⁴ by examining an American case study. This study showed that along with affecting the quality of surface water ecosystems, impervious cover decreases groundwater infiltration which affects water levels in aquifers. Setting a low total impervious cover threshold (approx. 10-15%, Schueler, T., 1994⁴⁵) protects the ecosystem as a whole.

The concept of reducing impervious cover in regards to road paving is a new concept for most areas. The decision to pave a road is usually based on safety issues and financial restraints. However, the municipality can take certain steps to reduce impervious cover—thus increasing infiltration—by for instance decreasing the width of roads (within provincial requirements) but increasing the gravel shoulder to ensure safety. The City of Vancouver has developed some sustainable alternatives to conventional roads such as the sustainable streets (see the Crown street project), and sustainable lanes (country lanes and centre strip paving) for residential lanes⁴⁶.



Meandering street and swale



Country Lane
© 2006, City of Vancouver,
Engineering Services

⁴³ Kapuskasing Groundwater Management Study

http://www.ene.gov.on.ca/envision/water/groundwater/moonbeam_opasatika/executive_summary.html

⁴⁴ Kauffman G.J., and Brant. T. (2000) *The role of Impervious Cover as a Water-shed-based Zoning Tool to Protect Water Quality in the Christina River Basin of Delaware, Pennsylvania and Maryland*

<http://www.wr.udel.edu/publications/imperviouscoverchristinabasin.pdf>

⁴⁵ Schueler, T. (1994) The Importance of Imperviousness. *Watershed Protection Techniques*. 1(3): 100-111.

<http://www.uppervalleyleague.org/storm2B.pdf>

⁴⁶ City of Vancouver, Engineering Services – Streets, Environmentally Sustainable Options

<http://www.city.vancouver.bc.ca/engsvcs/streets/design/enviro.htm> (last update 04/05/2006)

Preserving wooded areas allows for ground stability and water infiltration. Wooded areas provide better infiltration opportunities than natural grassland, which in turn are better than sod grasses. Preserving areas of natural landscape will preserve water quantity and quality, while protecting the ecological integrity of the region.

In Chelsea, a by-law has been developed to ensure that forested areas of the municipality are preserved. Clear cutting a property is illegal. Also, the zoning by-law states that a wooded buffer zone of 4.5m must be preserved at the boundary of each lot if trees are present on the property before building begins. Also, the municipality has the right to request that residents plant a buffer zone between properties.

5.1.6 Limiting water use

Outdoor watering by-laws

Water use restrictions are becoming increasingly common in Canada. Communities relying on surface water and/or groundwater are adopting regulations and bylaws to limit residents' rights to use water in order minimize potential water shortages. Restrictions are placed on water uses which are deemed not essential to human life. Examples of such restrictions include car washing, lawn or flower bed watering, etc. Some municipalities have even made wasting water illegal⁴⁷. When provincial law does not give individuals "rights of capture"⁴⁸ for groundwater, municipalities can chose to regulate outdoor water uses, such as lawn watering.

The most common way to impose a water restriction in North America is to limit a consumption heavy activity. For example, in some communities lawn watering is only allowed on certain days. This way, each resident gets the chance to use water for non-essential outdoor uses at least once per week. Alternatively, some municipalities only introduce lawn watering by-laws when water sources start to show signs of depletion. When such an event occurs, all lawn watering is restricted until the ban is officially lifted. The region of Waterloo⁴⁹ has developed a comprehensive three-tiered water-use-restriction bylaw where, as water sources decrease in the summer, restrictions become increasingly stringent. Enforcement of the restriction and penalties for parties who disrespect them also become more severe. Enforcing outdoor water by-laws is the main challenge for municipalities which have large lot zoning. Relying on neighbors to report illegal water uses is difficult because of the distance between properties. Installing and monitoring water meters on domestic water wells may be the most efficient way for municipalities to monitor water use.

⁴⁷ A By-law Respecting the Outdoor Use of Water and to Amend By-laws 33-90 and 38-92

[http://www.region.waterloo.on.ca/web/Region.nsf/8f9c046037662cd985256af000711418/06175693979A892A85256C5D005576AE/\\$file/OUTDOOR%20WATER%20USE%20CONSOLIDATION.pdf?openelement](http://www.region.waterloo.on.ca/web/Region.nsf/8f9c046037662cd985256af000711418/06175693979A892A85256C5D005576AE/$file/OUTDOOR%20WATER%20USE%20CONSOLIDATION.pdf?openelement)

⁴⁸ Groundwater rights vary for each province; speak to your provincial representative to find out about the guidelines in your province. Note that in Quebec, water use is regulated by the Groundwater Catchment Regulation, R.Q. c. Q-2, r.1.3, which is part of the enabling statute Environment Quality Act, R.S.Q. c. Q-2

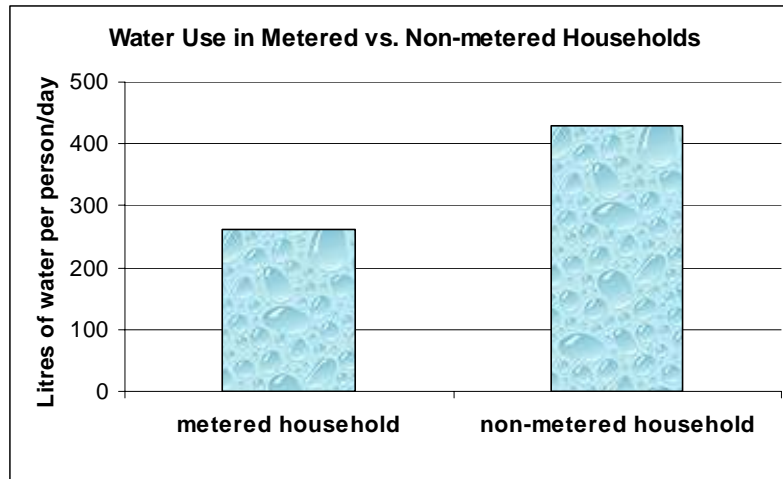
(<http://www.canlii.org/qc/laws/regu/q-2r.1.3/20060213/whole.html>)

⁴⁹ Outdoor Watering By-laws for all Municipalities in Waterloo Region

<http://www.region.waterloo.on.ca/web/Region.nsf/8f9c046037662cd985256af000711418/b23032db0472733f85256b03005de2f0!OpenDocument>

Metering

In 2001, approximately 61% of Canada's urban population was charged for water use by a metered approach⁵⁰. In rural areas, where water comes from domestic water wells, water extraction is often limited by regulations (ex. Ontario = 50,000L/day), but these standards are not monitored. Although metering water use from municipal systems is widespread in Canada and the United States, metering domestic wells is not common practice. Studies have shown that users charged according to consumption use less water than users whose water use is not monitored. Requiring installation of water meters on the water lines of domestic wells would give municipalities the capacity to monitor water use.



Source Data: Canada Mortgage and Housing Corporation (2000) *Household Guide to Water Efficiency*.

In Ontario, the Clean Water act ensures that each individual has the right to clean, plentiful and safe drinking water. However, the minister of the environment has clearly stated on several occasions that the present government has no intention or interest in installing meters on private residential wells. This stipulation, indicating that the provincial legislature will not impose the use of metering to domestic well users, does not imply that obliging residents to install water meters on residential wells by municipal by-law is illegal.

In Quebec, there are no regulations regarding water quantity use for private wells (only communal and high production wells). However, their sustainable development plan does indicate that “people are entitled to a healthy and productive life in harmony with nature.”⁵¹ Therefore, municipal actions taken to ensure environmental protection and quality of life such as groundwater quantity protection could be allowed.

⁵⁰ Environment Canada, 2004 *Municipal Water Use Report, Municipal Water Use, 2001 Statistics*
http://www.ec.gc.ca/water/en/info/pubs/sss/e_mun2001.htm (Last updated: 2005-02-21)

⁵¹ Sustainable Development Act (Bill 118, Chapter 3)- Assented 04/29/2006
<http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=5&file=2006C3A.PDF>

5.1.7 Performance standards

Developing well performance standards as well as critical threshold limits can decrease the odds of experiencing water shortages for new wells. Thresholds can be set based on studies focusing on similar aquifers, or a study could be commissioned by the municipality for the specific property in question. Upholding these standards would put the onus on persons who are proposing to develop infrastructure. They would be required to do aquifer tests (e.g. pump tests) to prove to municipal planners that water quantity is sufficient to support the proposed development. For example, a 72 hour pump test could be a requirement before permitting new developments. Communities can choose to legislate aquifer performance standards on all undeveloped lands, or only in certain regions of the municipality such as groundwater protection areas, or areas identified by census (i.e. H₂O Chelsea Water Questionnaire or Water Census) as demonstrating a high rate of well water shortages.

In Quebec, any new well drilled must comply with construction, location, and water quality standards outlined in the *Regulation Respecting Groundwater Catchment*⁵². Further standards for quality and quantity are given for communal wells. In Chelsea, the stipulations of these regulations are applied to drilling any high yield well in areas identified by the Comprehensive Development Programmes (or CDP see section on special permitting). The CDP was written in a way to allow municipal planners the option of requesting that aquifer tests be done prior to allocating building permits, particularly in areas with a higher potential for water quantity problems.

5.1.8 High yield systems

Developing shared high yield production wells in unproductive aquifers promotes ease of monitoring for water quantity and quality. The municipality can easily install water meters at each residence and impose taxes to each residence based on water consumption. These fees cover the costs of drilling the well, maintenance costs, water quality testing, and water distribution. These communal-type systems allow for drilling deeper wells to access a water source, while keeping costs to individuals low. These deeper aquifers, also known as regional aquifers, usually contain more water. High-yield systems are typically built to accommodate 2 to 25 homes. Note that when such a community system is built, the burdens of maintenance and development costs are sometimes given to the municipality.

Many communities across Canada use communal wells on their own or as a secondary water source with surface water. For example, water distributed in Waterloo Region (Ontario) comes from two sources: surface water (20%) and groundwater (80%). This region has developed an extensive Water Resources Protection Strategy for monitoring programs protecting the quality and quantity of water (surface and groundwater). An extensive groundwater quantity assessment, the Regional Groundwater Modelling Project⁵³, is presently underway as the community is

⁵² Regulation Respecting Groundwater Catchment
<http://www.mddep.gouv.qc.ca/eau/souterraines/index-en.htm>

⁵³ Regional Groundwater Modelling Project

planning to increase water extraction. This community also has several initiatives⁵⁴ to incite residents to reduce their consumption, to alleviate the stress imposed on the municipal water system.

5.1.9 Construction requirements

When new residences are being built, the municipality may require developers to offer the option of installing water conservation devices to potential homeowners. For example, low-flow showerheads, low-flow toilets⁵⁵, and faucet aerators have been shown to significantly decrease water use. The use of water conservation devices is not legally required by provincial Building Codes. However, recommendations in the engineers report for septic systems are to install water conservation devices to minimize water use, thus extend the life of the septic system. Municipalities are encouraged to support these recommendations.

Since August 1, 2005, the City of Calgary's Water Utility Bylaw requires all new homes and commercial construction, including renovations that require a plumbing permit, to install low water-use fixtures. Changes were made to this bylaw along with the initiation of other water conservation programs in an attempt to reduce water consumption for domestic purposes in Calgary⁵⁶.

5.2 Voluntary water conservation programs

Residents and business owners can decrease their water consumption in a variety of ways. The municipality can offer educational materials explaining the importance of protecting groundwater and how small changes can make a difference for the whole community. Various education guides for water conservation in and around the home were listed in section 1.1 (water kits) of this manual. Please note that many of the ideas listed below could also be considered for regulation.

[http://www.region.waterloo.on.ca/web/region.nsf/97dfc347666efede85256e590071a3d4/37A888F08FD43A5C85256E430075588B/\\$file/MODELLING.pdf?openelement](http://www.region.waterloo.on.ca/web/region.nsf/97dfc347666efede85256e590071a3d4/37A888F08FD43A5C85256E430075588B/$file/MODELLING.pdf?openelement)

⁵⁴ Region of Waterloo, Water Services

<http://www.region.waterloo.on.ca/web/Region.nsf/8f9c046037662cd985256af000711418/37A888F08FD43A5C85256E430075588B?OpenDocument>

⁵⁵ Canadian Mortgage and Housing Corporation Maximum Performance Testing of Popular Water-Efficient Toilet Models

<http://www.cmhc-schl.gc.ca/odpub/pdf/63511.pdf> (May 2004)

⁵⁶ Low Water Use Fixture Requirement

http://www.calgary.ca/portal/server.pt/gateway/PTARGS_0_2_780_237_0_43/http%3B/content.calgary.ca/CCA/City+Hall/Business+Units/Water+Services/Water+Conservation/Indoor+Water+Conservation/Low+Water+Use+Fixture+Requirement+.htm

Information Pamphlet on the *Low Water Use Fixture Bylaw* in Calgary

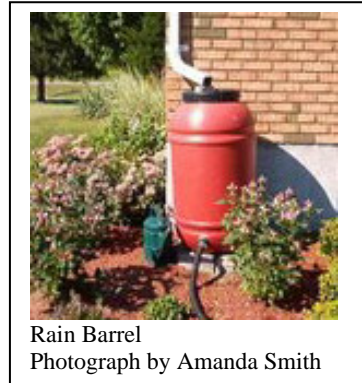
http://www.calgary.ca/docgallery/BU/water_services/conservation/indoor/low_water_use_fixtures_07_05.pdf

5.2.1 Outdoors water conservation

Landscape watering

Municipalities who do not wish to (or that are not legally entitled to) place limits on landscape watering may choose to *recommend* landscape watering limits. For example, the municipality may recommend watering the grass only once a week, or recommend that watering only occur at times when evapotranspiration rates are lowest (dusk and dawn). Irrigation clocks and timers are useful tools which control the amount of water being used and the duration of watering.

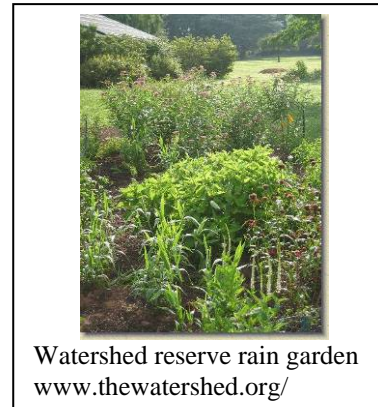
The use of rain barrels is a great way to reduce the use of groundwater required for landscape watering. The Municipality of Chelsea acts as an intermediate for the sale of rain barrels at a group rate. Advertisement for these items is done through the local newspaper. The program has been very well received by residents. To date, over 350 subsidized rain barrels have been purchased. For more information on how to use rain barrels see the Rain Barrel Guide⁵⁷.



Rain Barrel
Photograph by Amanda Smith

Decreasing impervious cover

Communities can educate individuals regarding the importance of decreasing impervious surfaces on individual properties by reducing paved surfaces and increasing vegetated areas. Keeping lawns fully vegetated, especially with plants having complex root systems, helps increase water infiltration and soil water retention, thus increasing groundwater recharge.



Watershed reserve rain garden
www.thewatershed.org/

Natural landscaping

Municipalities can prepare educational sessions or packages to distribute information on natural landscaping and low-demand vegetation which thrives in your ecozone. Planting drought-resistant grasses and shrubs in yards is a great way to keep a property visually attractive, while protecting groundwater sources. Building rain gardens⁵⁸ also helps water infiltration. Many books and websites⁵⁹ are available on drought resistant plants and building rain gardens.

⁵⁷ Rain Barrel Guide – How to use rain barrels for water conservation - <http://rainbarrelguide.com/>

Constructing a rain barrels - <http://home.comcast.net/~leavesdance/rainbarrels/construction.html>

⁵⁸ A rain garden allows bioretention of water; a system of pond, soil, mulch and plants which help retain and infiltrate water.

⁵⁹ Canadian Mortgage and Housing Corporation, Low Maintenance lawns
http://www.cmhc.ca/en/co/maho/la/la_004.cfm (May 2006)

Canadian Mortgage and Housing Corporation, Rain Gardens: Improve Stormwater Management in Your Yard
http://192.197.69.106/en/co/maho/la/la_005.cfm (June 2006)

Canadian Wildlife Federation – Get wild about Growing <http://www.wildaboutgardening.org/en/growing/index.htm>

Agriculture and Agri-food Canada, Plant Hardiness Zones in Canada <http://sis2.agr.gc.ca/cansis/nsdb/climate/hardiness/>

Beautiful lawn and gardens through Water efficient landscaping <http://www.ocwa.com/uploaddocuments/garden02.pdf>

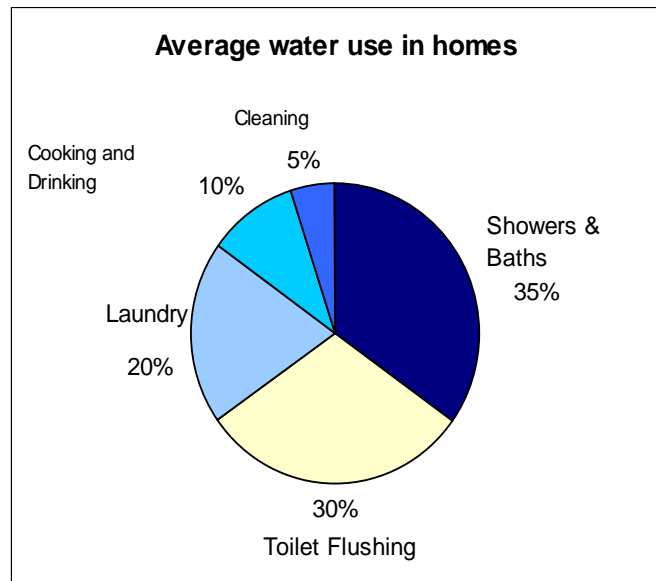
Other personal choices to reduce water use outdoors

Residents need to be informed about water conservation options around the house and in the community. For example, local car wash stations which recycle water are more water efficient than washing cars at home. Dry sweeping driveways and paved areas instead of using flowing water is also better for water conservation. For more water conservation ideas please visit the Environment Canada Freshwater⁶⁰ website.

5.2.2 Water efficiency of homes and buildings

Water conservation devices

Many water conservation devices are available on today's market, such as low-flow showerheads, low-flow toilets or fill diverters, toilet leak detection tablets, faucet aerators, etc. Municipalities can prepare education booklets about some of this technology to encourage its residential use. Alternatively, the municipality can team up with a local hardware store; the municipality might advertise products of choice while the store offers discounted prices. Some areas offer monetary incentives to residents for using water conservation devices. The City of Calgary has a residential toilet replacement program, where a sum of money is given to residents who change their old high flow toilets with new water conservative models. This program is part of a campaign to reduce water consumption where community education programs along with financial incentives aim to change Calgarians water consumption patterns to reduce water use in the city.



Source Data: Water Use in the Home.

<http://www.ec.gc.ca/water/descrip/manage/effic/a6f7e.htm>.

Environment Canada, 2005.

Water Conservation Appliances

Water conservation appliances have recently become quite popular. For example, front loading washing machines and high-efficiency dishwasher's use much less water and are more energy efficient than conventional appliances. Installing an irrigation system automates lawn watering and helps ensure that the activity is done when most efficient (i.e. dawn and dusk). Visit Environment Canada's Ontario Region interactive website on water conservation⁶¹ for tips on retrofitting homes to reduce water consumption.

⁶⁰ Environment Canada, Water Efficiency/Conservation
http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm (Last updated 2004-06-10)

⁶¹ Environment Canada – Ontario Region – Water Conservation Tips
http://www.on.ec.gc.ca/reseau/watertips/watertips_flash_e.html (Interactive)

5.2.3 Water conservation for multi-residence buildings, businesses, and industry

Multi-residence buildings and the industry and business sectors are also important water consumers. Many options exist to improve the resource use in these buildings. Making buildings water and energy efficient at the beginning of their life-cycle, eliminates the costs of retrofitting them in the future and saves money by decreasing water and energy use from the start. A water pump uses a lot of electricity and therefore using water conservation devices and appliances will reduce stress on the pump, thus extending its life. Also, using water conservation devices will reduce the amount of water being put into the septic system. The *Advanced Buildings, Technologies and Practices*⁶² was written by a public and private partnership to recommend environmentally-appropriate technologies and practices for buildings. The scope of this guide includes energy and resource conservation initiatives, including water conservation. The Department of Public Works and Government Services Canada also developed a comprehensive guide, *The Environmentally Responsible Construction and Renovation Handbook*⁶³, which details environmental stewardship initiatives for buildings in Canada; chapters 6 and 7 discuss water conservation.

Encouraging water conservation for industry is also important. Water intensive processes could potentially deplete water resources in groundwater dependant communities. The government of Ontario has prepared a *Green tips* document⁶⁴ for water conservation in the industry sector.

6. Concluding remarks

Will the overdrawn of groundwater and/or the effects of global climate change cause the well to run dry in your community? The precautionary principle dictates that it is wise to do what you can to avoid such a possibility.

With this in mind, the Municipality of Chelsea began implementing water resource protection initiatives in the early 1990's. Fifteen years later, the results of the H₂O Chelsea Water Questionnaire, Census and Static Level Program are helping the municipality understand the status of their aquifers, helping municipal planners to make enlightened decisions about groundwater use, development, and zoning. The municipal council has also implemented zoning regulations and policy initiatives in order to legislate the protection of Chelsea's groundwater. Prevention is often the best policy.

Perhaps the most important action on this front has been to distribute information to local residents. Most people want to make water-friendly decisions but are often unaware of the issues. To change personal behaviours, people need to be informed and see the concrete advantages

⁶² Advanced buildings, technologies & practices

<http://www.advancedbuildings.org/>

⁶³ Public Works and Government Services Canada - The Environmentally Responsible Construction and Renovation Handbook

http://www.pwgsc.gc.ca/realproperty/text/pubs_ercr/toc-e.html (Last Updated: 2005-08-25)

⁶⁴ Green tips- Water conservation tips for industry

<http://www.ene.gov.on.ca/cons/3781-e.pdf>

(financial and environmental) of implementing water conservation initiatives and policies at home and at the community level.

The aim of this manual has been to document practical and affordable opportunities that exist for communities to monitor, understand and legislate the protection of their groundwater resources. We hope other municipalities will act proactively and implement a groundwater program in their community. Do not hesitate to contact us in order to discuss how you can modify H₂O Chelsea's groundwater quantity resources for use in your municipality.

We look forward to working with you!