



## Groundwater Program Newsletter

### Groundwater News

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### Editor's Message

« The policies we adopt for the development of our water will have a profound effect in the years to come upon our domestic, agricultural, and industrial economy. »

Dwight. D. Eisenhower (1957)

Water for life – the title defined by the United Nations as the International decade for Action (2005-2015), outlines in its second report that water is a shared responsibility. As we are all living in a changing world, water management need to be coordinated with sustainability in mind. To be able to attain this state of action, few steps need to be put in place first. Regional assessment of aquifers – mapping the land in order to understand the water contexts – is the beginning of a series of building blocks. Once the land is appropriately characterized (topography, geology, land uses...), it becomes possible to monitor groundwater movement and its fluctuations, and the only way known to man to achieve this is with a network of groundwater observation wells, time and continued financial support. Groundwater monitoring is a long-term commitment.

To monitor, or monitoring, generally means to be aware of the state of a system. Monitoring is an action through which one observes a situation for any changes which may occur over time, using a monitor or measuring device of some sort. Given the issue of scales in space and time of groundwater flow and its interactions with the hydrologic cycle, monitoring is an action of extreme importance. Yet, this is often

not well understood, nor fully considered, in the study of groundwater. **The main theme of this issue is groundwater monitoring.** Thus, this entire newsletter is devoted to the rational of monitoring groundwater as the enhanced emphasis on data and information is the only way that will benefit a sound decision making process toward sustainability. It is also a plea to all stakeholders to unite their actions toward knowledge development and sustainability.

A new, although rather hesitant initiative, is slowly emerging thought the NAT - the National Administrators Table (surface water). I was recently invited to participate in the NAT's annual meeting in Niagara Falls to discuss the potential of establishing a joint surface water/ groundwater national network. I proposed a management framework where monitoring, data and models would be closely interrelated and would be used as integrated tools to manage the groundwater resource. I went back to the results of the national workshop on groundwater monitoring that I had organized and that many of you attended in Winnipeg in October 2003. The question was left opened for further analysis and discussions. My presentation is available upon request.

As Eisenhower expressed his belief in 1957, with the International Geophysical Year Program, that "the most important result is that demonstration of the ability of peoples of all nations to work together harmoniously for the common good. I hope this can become common practice in other fields of human endeavour." I too hope this will come true on a local-regional-provincial-national scale for groundwater studies and monitoring.

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## **The rational behind monitoring**

The second phase of the Groundwater Mapping Program is a renewed commitment to Canadians to insure abundant and long lasting supply of clean water for immediate and future uses. The Earth Science Sector (ESS) of Natural Resources Canada is helping with the evaluation of available potable groundwater by mapping and studying prioritized Canadian aquifers.

Phase II of the groundwater program (2006-2009) is a response to the overall long-term goal of establishing a national groundwater inventory and database. The Canadian Framework for Collaboration on Groundwater (Rivera et al, 2003) outlined that a national groundwater inventory would serve various purposes which includes the assessment of "key" regional aquifers in Canada. Monitoring of groundwater becomes the natural process to put forth the information detailed by prior assessment of aquifers. Comprehensive groundwater studies require time and devotion. Such a commitment needs availability of expertise and data to insure efficient decision-making processes for sustainable use of groundwater and preservation of its quality.

### **Why Monitoring?**

Throughout the world, groundwater well networks have been established for a number of reasons. Canada has developed its expertise with groundwater monitoring since 1970. Multi-institutional researches have been coordinated to describe provincial and territorial aquifers. Knowledge development is an important aspect in an ever changing world and determines our capacities to adapt as well as to anticipate developments in an efficient manner.

Funding groundwater research often escapes budgetary provisions as the mentality of abundance of water reflects a general attitude that comes with the perception of water availability and accessibility. Communities dependent upon groundwater are encouraged to consider and incorporate measures to protect groundwater within their community planning activities (Government of British Columbia – Web site of the Ministry of Environment, Water Stewardship Division). Groundwater withdrawals for public supply and irrigation are continuing to rise (Hutson et al, 2004). As an important reserve of fresh water, groundwater requires periodic inventory and ongoing monitoring to develop and enhance modelling.

Data collection and monitoring enable a long-term understanding of groundwater supply and the anthropogenic effects of diversity of uses throughout the land. Addressing the environmental effects of groundwater development on land and on surface-water resources become a priority for decision makers for whom tools and policies need to be tailored to the reality of groundwater. Therefore, monitoring data used in parallel with mapping and modeling, reflect a complete picture of the aquifer conditions needed for the proper and full assessment of the resource and benefit the decision-making process.

### **Role of monitoring**

Groundwater monitoring is the systemic collection and evaluation of data and represents a significant component of the assessment of the state of the resource. Monitoring groundwater levels is an essential action to complete the assessment of a comprehensive water management process. The results of monitoring set the diagnosis for the availability and quality of groundwater resources.

## **Objectives of monitoring**

Monitoring water levels and water quality provide information for developing our comprehension of the resource. A well designed monitoring program defines water quality problems, characterizes existing and emerging problems, determines the magnitude and geographical extent of water conditions, provides the basis for designing and operating pollution prevention and sustainable uses programs, and most importantly, it identifies trends in the water characteristics over time.

### **Methodology and use of data**

To monitor groundwater, a long term commitment is needed for its efficient study and comprehension. An adequate methodology should include equipment, a plan with the frequency of measurements, quality assurance and data reporting. A network of wells equipped with data loggers and telemetry systems that continuously collect and upload water quantity data to a groundwater monitoring information system in real time is a key function in the development of groundwater knowledge. The frequency of measurements is one of the most important considerations in the design of a water-level monitoring program. The development of a plan for water-level monitoring that will be used for each well in the observation network is dependant on the objectives of the program and the intended use and level of analysis required of the data. The frequency of measurement should be adequate to detect short-term and seasonal groundwater fluctuations of interest and to discriminate between the effects of short-term and long-term hydrologic stresses. For instance, the frequency could be designed as a function of aquifer type, of the groundwater flow and recharge rates, of aquifer development (pumping) and climatic conditions (changes). Shallow aquifers need more frequent measurements, while deep confined aquifers need less. Aquifers with less withdrawal (less pumping) need less frequent measurements, whereas aquifers in full development or over-development (greater withdrawals) need more frequent measurements.

This collection of data is then charted, reported and analyzed to provide an accurate assessment on ambient groundwater conditions, early warnings for change in water quantity (caused by climatic conditions, land uses changes or water taking permits), and water quality due to natural or anthropogenic causes. It also provides identification of emerging issues of both water quantity and quality nature. Information supporting land-use planning decisions, sound groundwater resource management and policy decision on a watershed, or aquifers, basis would greatly benefit from data collected in a coordinated network of observation wells.

### **Monitoring priorities**

The first phase of the ESS National Groundwater Program (2003-2006) provided hydrogeological information, maps, publications and models useful for the management of groundwater resources. This important data collection comprises information to be developed further. In addition, observation wells networks would serve to:

- Assess the impact of groundwater withdrawals in specific areas to determine if further groundwater development is possible without depleting the resource;
- Assess groundwater supply problems, including well interference between individuals using the same aquifer;
- Assess and attempt to resolve surface water-groundwater use conflicts such as groundwater withdrawal near fully allocated streams;



- Assess the long-term and short-term effects of natural and human-induced factors such as pumping, construction of drainage works and global climate change on groundwater levels;
- Forecast groundwater changes due to drought and flood conditions;
- Assist in resource evaluation, inventory and management to support water resources planning and effective utilization of the groundwater resources; and
- Monitor the effects of human activities on groundwater quality.

### Status of monitoring

The monitoring of groundwater level has been done in site-specific contexts. The absence of any knowledge of groundwater resources formed the impetus of the development of groundwater level observation well network. Most of the wells and piezometers have been installed to monitor local problems or were constructed as part of regional studies. Generally, wells are constructed for observation purposes or drilled as test holes, and then converted to observation wells. Existing networks have been all targeted by budgetary disposition and redeem a discontinuous attention process. Nonetheless, somehow the monitoring has been managed to keep the minimum of infrastructure operating.

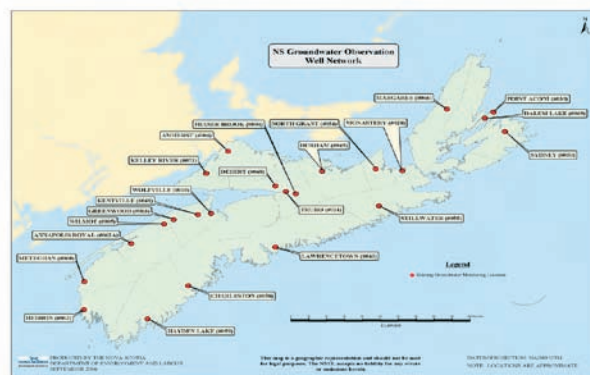
### A few examples are shown below at the provincial level.



#### Nova Scotia

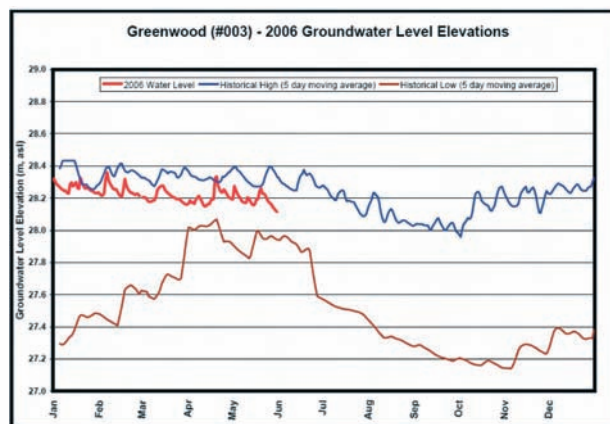
Nova Scotia's groundwater monitoring network was established in 1965 as part of the International Hydrologic Decade (1965-1974). Succession of priorities enabled the network to expand up to 40 active wells. However, by 1984, it had been reduced to 28 active monitoring wells. Many years of raw data are available, although there are periods with data gaps. Currently, the network includes 14 wells located across the province, with 9 more wells were recently added.

The wells are equipped with electronic dataloggers and telemetric units that record water levels every hour and transmit the data to a central computer in Halifax. Their primarily used is to monitor groundwater levels, drought conditions, assessing the impact of human activities on groundwater and evaluation of long-term groundwater trends associated with issues such as climate change. Water samples are collected from the wells periodically and tested for parameters such as: major ions and cations, metals, volatile organic compounds, pesticides and tritium. The wells are visited approximately every six months for field verification.



Map of observation well locations in Nova Scotia

Groundwater monitoring results from the Nova Scotia Groundwater Observation well Network are now available to the public on-line. Result can be viewed at: <http://www.gov.ns.ca/enla/water/groundwater/groundwater.asp> or by visiting Nova Scotia Environment and Labour's Groundwater Webpage: <http://www.gov.ns.ca/enla/water/groundwater/> and following the links to the Groundwater Data section.



Example of short-term water level graph at Greenwood, N.S Québec

#### Québec

The groundwater observation well network in Québec dates from the early 1970's and continued until 1994 when most of the network was shut down because of budgetary cuts. Between 1970 and 1985, a series of regional studies was conducted by the Ministère des Ressources Naturelles du Québec (Ministry of Natural Resources). These studies highlighted several local problems and most of the wells for the network were drilled in order to understand and monitor groundwater. In 1996, as part of a GSC hydrogeological mapping project, 4 observation wells were constructed and levels were monitored in the Portneuf region. In 1997-98, 10 wells were rehabilitated and continuously monitored for groundwater levels in the area of contamination at Ville Mercier. In 2001-02, as part of the Mirabel aquifer project, 10 wells were installed by the Geological Survey of Canada. In 2003-2004, 21 wells were installed for the joint (ESS, MDDEP) Châteauguay Hydrogeological Regional Assessment Project.

## Ontario

An Ontario Regional Provincial Groundwater Monitoring Network of 450 instrumented wells has recently been established by the province in partnership with the 36 Conservation Authorities and 10 municipalities. The network specifically monitors groundwater levels and quality to determine long term trends and emerging issues. A complimentary program also exists for water quality and flow monitoring of Ontario streams including sampling during periods of low flow, which, in many cases, can be used to infer groundwater quality.

## Saskatchewan

The Saskatchewan Research Council (SRC) established and operated a groundwater well observation network since the mid 1960s that included 54 wells and 3 surface water sites. The operation and maintenance of SRC's network was transferred to the Saskatchewan Watershed Authority (SWA) in 2005. The SWA currently also operates and maintains a network of 15 wells. The objective of this network is focused on obtaining water level measurements in areas affected by pumping. The data from Saskatchewan's network will provide valuable long term information both on natural groundwater level fluctuations as well as on the impact of withdrawals on the various types of aquifers under stress. The latter information is used for aquifer management decisions.

## Observation (monitoring) enables science, policy and social issues

At a recent GSA annual meeting (Philadelphia 2006), Narasimhan (2006) provided a broader context of groundwater monitoring. In his presentation, he argued that to assure long-term sustainable supplies, groundwater systems have to be carefully managed. Such management entails knowledge of their physical, chemical, and biological attributes, the interrelationships among the attributes, their temporal changes due to natural causes and human actions, and the ecological and environmental impacts of such changes. The gathering of indispensable information required for this purpose constitutes "monitoring".

Narasimhan went on to described groundwater monitoring as a scientific enterprise being a rapidly fast growing field. He mentioned that the emerging challenges in this field include scientific-technical issues, as well as social-policy issues. From a scientific perspective, one need is to identify the set of critical attributes requiring observation, choose measurement sites, spatial distribution of monitoring stations and temporal frequency of measurement, and establish mechanisms for storage, retrieval and dissemination of data. Scientific objectives vary in scale from that of a single user on a local scale to the large scale basin wide interests of the community at large, and the interactions between groundwater and the ecosystem. As the field of groundwater monitoring progresses to enable sustainable management, it will face challenges of optimal network design, instrumentation, data acquisition, data adequacy, interpretation and dissemination.

Finally, Narasimhan suggested that groundwater monitoring processes are a joint venture between scientific-technical and social-policy issues which, simultaneously, will also face challenges of legislative authorization, institutional development and financial support. Amidst these challenges, monitoring will likely evolve into being an integral and permanent part of integrated water resources development.

## Groundwater Monitoring in the World

Let's see how Canada compares to other large countries of the world in groundwater monitoring. The table below is not comprehensive but shows an indication of the number of monitoring wells and the duration of the observations for each country.

| Groundwater use<br>(of total population) |      | Observation Wells <sup>1</sup>  |
|--|------|---------------------------------|
| U.S.A.                                   | 50%  | ~40'000 (1985), 20'000 (2005)   |
| Russia                                   | 36%  | ~15'000 (4.5k in Moscou region) |
| China                                    | ~15% | >50'000                         |
| India                                    | 32%  | >50'000                         |
| Mexico                                   | 66%  | ~10'000 (QT), 5'000 (QL)        |
| France                                   | ~30% | >10'000                         |
| Canada                                   | 30%  | ~1'500                          |

<sup>1</sup>(5 or more years of record); QT=quantity; QL=quality

We can see from the table that most of those countries have recognized the importance of groundwater resources and the need of monitoring groundwater quantity and quality over time.

China uses 81% of its water for agriculture, 11% for industry and 8% for domestic uses. Surface water is still the main resource used. Both resources surface water and groundwater are known; and groundwater use is increasing at a pace of 8.5 % per year! China currently faces problems of declining of groundwater levels; subsidence due to over-pumping and saltwater intrusion in coastal aquifers. China has long recognized the importance of groundwater and this is reflected in their monitoring networks.

The USA has seen a drop in the number of observation wells in the last 20 years, but current trends indicate that there will be an increase again although more targeted: to monitor climate response, anthropogenic effects and ad-hoc wells, e.g., to track SW/GW interactions (Cunningham, 2006). Of the 20 000 observation wells the USA currently has, approximately 11 000 wells are monitored through the USGS Cooperative Water Program; and the rest by state agencies and OGDs.

In Russia, cities with less than 50 000 inhabitants rely on groundwater at 74% Cities with less than 500 000 inhabitants at 48% And cities with 500 000 to 1 million inhabitants at 34% Russia has two groundwater monitoring networks managed by the Ministry of Natural Resources and the Ministry of Land Reclamation and Irrigation; about half and half since 1990.

More than 65% of the land in Mexico is arid or semi-arid, thus Mexico heavily relies on groundwater for supply and irrigation. Water resources are managed by a central office on the federal government. Monitoring is thus centralized in the Comisión Nacional del Agua (CNA) or National Water Commission.

For long, France has adopted an IWRM approach using the watershed as their management unit. Groundwater monitoring wells in France are thus operated by the five Regional River Basins.

In Canada, groundwater has not followed the same pace of development as compared to other countries of the world. We do not see groundwater over-exploitation or declining water levels.



However this is slowly changing; we see instances of groundwater pollution (point and non-point sources), as well as conflicts of use and users; and we begin hearing that groundwater may be considered as a backup source for water supply in the case of severe climate changes and droughts. Consequently, we should also see an increase in groundwater monitoring; but let's not wait too long!

## References cited

Cunningham, W.L., 2006. Ground-Water Monitoring in the U.S. Geological Survey. USGS-EC-NRCan workshop, Vancouver, March 7, 2006. Presentation available on the program's web site.

ESS Groundwater Program first Phase, 2003-2006. [http://ess.nrcan.gc.ca/gm/bulletin/bulletin\\_v3.2\\_e.php#ex](http://ess.nrcan.gc.ca/gm/bulletin/bulletin_v3.2_e.php#ex)

ESS Groundwater Mapping Program second Phase, 2006-2009. [http://ess.nrcan.gc.ca/gm/proj\\_e.php](http://ess.nrcan.gc.ca/gm/proj_e.php)

Government of British Columbia – Web site of the Ministry of Environment, Water Stewardship Division [http://www.env.gov.bc.ca/wsd/plan\\_protect\\_sustain/groundwater/library/envass.html](http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/envass.html)

Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, K.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 46 p.

Narasimhan, T.N., 2006. Broader context of ground-water monitoring. GSA Annual Meeting paper No. 73-9 Philadelphia, USA, 22-25 October 2006.

Rivera, A., Crowe, A., Kohut, A., Rudolph, D., Baker, C., Pupek, D., Shaheen, N., Lewis, M., and Parks, K., 2003. [Canadian Framework For Collaboration on Groundwater](#). Government of Canada,

## Advances in groundwater research

The Geological Society of America 2006 Annual meeting in Philadelphia proved to be relevant in terms of advancement in groundwater research. The scientific community not only exemplified its expertise in hydrogeology but also demonstrated a greater understanding of what needs to be achieved for future knowledge development. The focus of several groundwater-related sessions was on the assessment and quantification of groundwater reserves as these are the first step that should be taken in evaluating the sustainability of regional aquifer systems. Groundwater needs to be defined for efficient management decisions to be made. It was argued that the scale of the resource's boundaries is critical to achieving a sustainable groundwater resource. Defining the availability of the resource includes resources assessments, mapping, characterization, monitoring and modeling.

Two major current issues were underlined during that meeting: the scale of the studies and monitoring. Excerpts from the presentation of Professor Graham Fogg (University of California) summarize the motivation for research developments and decision making as a whole: *The unknown, future groundwater quality in regional systems should therefore be a top research priority of the hydrologic community. Long-term groundwater quality and sustainability questions demand a complementary genre of research that is more regional in scope and covers longer time scales.*

One of the most impacting presentations was the one by Gene Whitney on "US National Water Census." Gene Whitney works for the *Office of Science and Technology Policy of the Executive Office of the President (of the USA)*. His presentation was very much enlightening and edifying for many of his points/arguments are very similar to the ones of the ESS Groundwater Program.

Mr Whitney mentioned that in the face of regional droughts and increasing conflicts over fresh water supplies, it was becoming increasingly obvious that the U.S. does not know how much water they have or how much water they need on a variety of scales. *"Without knowledge of ground water and surface water supplies, and how they change over time, water managers cannot know whether supplies will be adequate to meet critical needs over the coming decades."* He went on indicating that *"just as it is critical to the Nation to have current information on population, economic activity, agriculture, energy, and public health, it is also critical to know the status of our fresh water resources over time."*

His office has recommended to the Executive Office of the President that, in partnership with state, regional, and local water agencies, Federal agencies may devise an interagency national strategy for conducting a National Water Census; that is, a periodic inventory of the nation's surface water, groundwater, and water quality. *"Such a census would require us to develop and adopt data collection, data communication, and data availability standards and protocols for all surface water, groundwater, and water quality measuring and monitoring systems nationwide. A census would integrate existing water monitoring networks to provide uniform water measurements nationwide, and would develop a strategy to establish regional and national priorities for the highest level needs for surface and groundwater monitoring in the U.S. Such a water census might also include implementation of the National Water Quality Monitoring System."*

Researchers at the Earth Sciences Sector can be assured of the orientation of the National Groundwater Mapping Program as it is also driven to regional-scale resource assessment, monitoring, vulnerability (prevention), sustainability and resource management. These are developed with the support of provincial partners and within the program's limited budget.

## People in the news

**From groundwater to Jupiter, story by Steve Grasby, PhD GSC-Calgary**

The 3 main ingredients for life as we know it are energy, water, and carbon. Other than Earth the mostly likely planetary body to have these 3 critical ingredients is Jupiter's moon Europa, making it the highest priority for NASA's next deep space mission. Europa has an active surface geology and abundant evidence for a global ocean under its icy shell. Another intriguing feature of Europa is the 'dark terrains' which spectral data suggest are sulphur compounds extruded through cracks of the icy shell onto the surface. Previous work on sulphur springs discharging through glacier ice in Canada's High Arctic by Stephen Grasby and his colleague who first discovered the site, Benoit Beauchamp, has drawn the interest of NASA. A team of scientists led a return visit to the site in the summer of 2006 as a growing interest requested more information. Two main goals were the collection of spectral data from the site for comparison to that retrieved from Europa, and the characterization of the microbiological

communities living within the spring system. Work at the site is also improving our understanding of groundwater flow in mountainous terrain as well as flow in regions of thick permafrost (~500 m). Given that the site lies within a major sedimentary basin that will likely be the focus of future oil and gas production, this base level knowledge



*Steve Grasby measuring pH at a sulphur spewing source*

prior to industrial development is critical.

Results from the summer work demonstrate that the sulphur springs are highly dynamics, shifting across the glacier from year to year. The spring discharge was much higher (~8 l/s) and more saline (~8000 mg/l) than previously recorded. This is likely due to warmer conditions when previously visited, so that spring discharge was diluted by surface melt and also lost through basal groundwater flow. A large volume of proglacial ice was observed, along with layered salt deposits that were not previously present, suggesting that the spring discharge could be perennial, flowing through the cold winter months. Another significant discovery was the recognition of small pipe-like chimneys that are rich in sulfate minerals. These are believed to be dried-up ancient spring sites.

The team performed multiple spectral measurements of the sulphur-stained ice as well as of the unblemished ice nearby in an effort to ground truth spectral data collected at the same time by satellite. The project is now awaiting results from laboratory analyses that will tell researchers the extent and vitality of the bacterial population within the ice. The undiluted nature of the water samples should yield some fascinating results.

### **Suggested reading**

In this issue, the list of suggested readings is a compilation of a few of the most relevant publications which have come to the attention of the editor. If you are interested in obtaining copies of some of these references, please contact Isabelle Martineau, at (418) 654-2677 or Email to [Isabelle Martineau](mailto:Isabelle.Martineau).

Maathuis, H. (compiler), 2005. Groundwater Observation Well Networks in Canada. Report by SRC with contribution from all Provinces, containing 13 tables and 13 figures.

Rivera, A., Côté, P. and Ferguson, G., 2003. Federal-Provincial Workshop: Groundwater Levels and Groundwater quality monitoring Networks. Minutes report. Winnipeg.

Science and Technology to support Fresh Water Availability in the United States, Report of the National Science and Technology council Committee on environment and Natural Resources – Subcommittee on Water Availability and Quality (2004). It can be downloaded at: [http://www.ostp.gov/nstc/html/swagreport\\_2-1-05.pdf](http://www.ostp.gov/nstc/html/swagreport_2-1-05.pdf)

Taylor, C.J., and Alley, W.M., 2002. Ground-water- level Monitoring and the Importance of Long-term Water-Level Data, Circular 1217, U.S. Department of the Interior, U.S. Geological Survey.

The Earth Science Sector – Natural Resource Canada: Groundwater Program 2003-2006, Structure program and thematic research subjects and coordination. [http://ess.nrcan.gc.ca/gm/logic\\_e.php](http://ess.nrcan.gc.ca/gm/logic_e.php)

Water: a shared responsibility – The United Nations, World Water Development Report 2. available at <http://www.unesco.org/water/wwap>

Water Stewardship Division – Ministry of Environment, Government of British Columbia [http://www.env.gov.bc.ca/wsd/data\\_searches/obswell/index.html](http://www.env.gov.bc.ca/wsd/data_searches/obswell/index.html)