Data Management - the Most Under-Appreciated & Under-Funded Aspect of Groundwater Management?

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ABSTRACT
The York Peel Durham Toronto – Conservation Authorities Moraine Coalition(YPDT-CAMC) groundwater management program was set up to foster the sharing of information, knowledge and technical expertise across a vast portion of south-central Ontario. Over the past ten years a data management system has been maintained by a small number of dedicated individuals. Design of the database was such that it enabled linkages between many different sources of data that are relevant to groundwater studies and to accommodate different types of water data that are necessary for responsible groundwater management. For Ontario to rightfully make a claim as a global water leader, a focus on water related data should be at the heart of such a claim.

RÉSUMÉ
Le programme de gestion des eaux souterraines York-Peel-Durham-Toronto -- Conservation Authorities Moraine Coalition (YPDT - CAMC)) et de l'Office de protection de la nature de la moraine Oak Ridges (CAMC) a été mis en place pour favoriser le partage d'informations, de connaissances et d'expertise technique à travers une vaste portion du centre-sud de l'Ontario. Au cours des dix dernières années, un système de gestion des données a été maintenu par un petit nombre d'individus dévoués. La base de données a été développée pour permettre de nombreux liens entre les différentes sources de données qui sont pertinentes dans le cadre des études des eaux souterraines La base de données a également été conçue pour répondre aux différents types de données sur l'eau qui sont nécessaires pour la gestion responsable des eaux souterraines. Pour que l'Ontario revendique légitimement son titre de leader mondial de la gestion de l'eau un accent sur les données relatives à l'eau doit être au cœur d'une telle position.

1 INTRODUCTION

The effective management of Ontario's groundwater resources is dependent upon ready access to well organized, high quality data. In this regard, there are opportunities for Ontario to move forward by integrating existing water management datasets. In the Oak Ridges Moraine area of south-central Ontario a partnership program involving 13 government agencies, has developed a robust data management system that is being used to support Source Water Protection as well as other groundwater based initiatives. It is believed that the database methods implemented in this area can be extended to other parts of the province.

From a groundwater perspective the Province currently manages only one Province wide dataset: the Water Well Record Information (WWIS) database. This far-sighted dataset was established in the mid part of the 1900's and has grown to encompass detailed information on over 600,000 wells. Despite its early initiation, this far sighted program has suffered over the years from a lack of investment - both in terms of dollars and in terms of imagination. There are several areas in which the current Provincial dataset falls short and where improvements can be made. The opportunities to expand upon this core dataset to build a truly effective groundwater management system can be grouped into several categories including:

- expansion (of wells in the database);
- improved data collection requirements and tighter QA/QC;
- incorporation of temporal data;
- incorporation of subsurface geological framework; and
- integration of other provincial datasets.

This paper discusses the components of the suggested groundwater management system and also touches on the trials and tribulations of establishing such a system. For example, the maintenance of the database continues to prove challenging from a variety of aspects.

2 YPDT-CAMC OAK RIDGES MORAINE HYDROGEOLOGY PROGRAM

This groundwater management program, unique certainly to Ontario and perhaps to all of Canada, involves the co-operation of 13 government agencies to advance their understanding and management of groundwater by pooling resources to more effectively build a groundwater "knowledge management" system.

The origins of the program date back to the late 1990's, a time when the Province adopted a 'hands-off' approach with respect to land-use management in the areas surrounding the City of Toronto. The Regional Municipalities of York, Peel and Durham were hearing from their constituents loud messages of discontent with how development was advancing onto the Oak Ridges Moraine. Specifically, the lack of environmental information as it related to potential impacts of the encroaching development upon the groundwater system was of paramount importance. The City of Toronto also joined the partnership, recognizing that new development

to the north of the City in the headwaters of the watersheds flowing through Toronto was a potential cause of enhanced erosion that was causing problems for city residents.

Similar issues were being discussed amongst the Conservation Authorities that had jurisdiction on the Oak Ridges Moraine. Through a Memorandum of Understanding which sets out the parameters surrounding the tasks to be jointly undertaken, all thirteen agencies have agreed to be partners in the groundwater program.

Figure 1 shows the generalized study area. Although the database now extends to cover the Source Water Protection areas that intersect onto the Oak Ridges Moraine, the more focused geological and hydrogeological work undertaken in the program has focused in the areas of York, Peel and Durham Regions and the City of Toronto.

Figure 1 - Study Area

3 JOB ONE - DATABASE MANAGEMENT

One of the first steps undertaken at the outset of the formal program was a decision to establish a robust integrated groundwater data management system. It was discussed at the time that the database system, if constructed properly, and effectively utilized, would become a magnet for groundwater practitioners, both from the viewpoint of wanting to access the database, but also from the point of view of wanting to ensure that their data was added to the database. The term "shovel-ready", a term frequently used to describe more "hard-core" infrastructure progams over the past few years, can certainly be applied to this database as well. Many groundwater studies collect data - usually at a high cost - and these data are then documented in short-lived reports before being orphaned and lost from the collective knowledge bank. These data can readily find a "home" in the database, thereby enhancing the overall groundwater management and knowledge system.

Initially capitalizing on the extensive work that had been done at the Ministry of the Environment with the WWIS, the YPDT-CAMC groundwater program has built upon this dataset. The structure of the WWIS database was re-designed to allow for the incorporation of additional borehole datasets as well as to accommodate temporal data such as pumping records, water quality data and water levels.

Since its beginnings the database has now grown to integrate five key groundwater related elements:

- wells or boreholes;
- streamflow measurement locations;
- climate stations;
- water taking permits; and
- groundwater related documents (reports and papers).

Each of these elements has several related tables within the database including tables that store related temporal data (e.g., water levels or daily precipitation, etc.).

4 OPPORTUNITIES FOR IMPROVEMENT OF GROUNDWATER DATABASE MANAGEMENT

4.1 Expansion

Through changes in legislation, enacted in 2003, the Ministry has already taken steps to ensure that boreholes drilled for consulting projects are now largely captured through the WWIS. However, compliance remains a problem since not all drillers report all the boreholes that they have drilled.

One additional step that could be taken by the Province - and the Water Resource Information Program (WRIP) program under MNR has shown some leadership in this regard - is to incorporate historical well data from various other sources. The YPDT-CAMC program has incorporated into the database several thousand additional wells into the program's groundwater database. In addition to those wells drilled in the past by hydrogeological and geotechnical consultants, the YPDT-CAMC dataset also includes wells drilled or collated by sister Ministries to the MOE (e.g., the old Urban Geology Automated Information System (UGAIS) dataset assembled by the Ontario Geological Survey under the Ministry of Northern Development and Mines; boreholes drilled by the Ministry of Transportation; and Oil and Gas wells that are collated by the Ministry of Natural Resources.) A similar initiative could be undertaken at the Provincial level.

4.2 Issues and Suggested Improvements for Data Collection Requirements and QA/QC

4.2.1 Tracking Changes to the Original Well Record

The WWIS system is largely overseen by only a few individuals at the MOE. As a result it has been difficult in the past to ensure firstly, that the data reported by well drillers is complete, and secondly, that the data entered into the Province's digital database has been entered correctly. Historically, when errors are caught by those external to the MOE it has been difficult for those errors to be corrected in the Ministry's WWIS. There was a reluctance to change the "original" database even when errors were known. The database was not initially designed to incorporate and track corrections and enhancements that are needed to refine and improve such a database. To handle changes to the original data,

a system of comment fields has been established within the YPDT-CAMC database so that corrections to the data can be made while at the same time recording the justification for any changes. It is deemed very important to both maintain the original data and also note where changes have been made and why.

4.2.2 Wells with No Reported Screen

With ongoing Source Water Protection work, as well as other recent groundwater modelling studies, there is a need to assign the screened interval from each well to a particular geological unit for the purposes of model calibration. The WWIS database provides the depth of the well and, only when reported, also stores the top and bottom depths of the well screen. A significant concern that has been noted is the infrequency with which drillers report to the Ministry the well screen details. Overall, within the WWIS only about 18% of the wells have a reported screen. The numbers improve somewhat if the bedrock wells are removed. Only about 6% of bedrock wells have reported screens and therefore the remainder can be assigned to an "open hole" category with the inherent assumption that water enters the well from the entire unscreened "open hole" interval. Complicating this type of analysis is the fact that many drillers incorrectly use the term "open hole" to identify the annular space around the well screen in many of the overburden boreholes. Tightening up on the use of the term "open hole" within the borehole construction table would serve to reduce confusion between bedrock and overburden wells.

For the wells that are completed within the glacial sediment above the bedrock only about 50% have reported screens. It is uncertain as to whether the remaining wells simply have no screen (i.e., the well is developed using air to leave a coarser grained sediment in the bottom of the well) or whether the driller failed to report the screen. For these wells, any recorded water level data either has to be omitted from analyses or the well has to be manually assigned a screen top and bottom. In the case of the YPDT-CAMC database these wells have been assigned an assumed default screen of 0.3 m length at the bottom of the well.

4.2.3 English versus Metric Units

A more disconcerting issue has arisen resulting from changes to the well record submission form. As an example, over the past ten years or so, the well record form has been changed to allow drillers to report the depth of their drilling/construction in either feet or metres. In many instances the boxes to indicate feet or metres are unchecked, thus leaving data entry staff to guess at the units of measure being used. This has introduced significant errors to the database. Perhaps restricting the drillers to one unit of measurement would resolve this problem.

4.2.4 Matching Information to Well Records in the Database

A further issue is the removal of the well owner from the MOE database owing to privacy concerns. With no access to the original well record submission form it is difficult in many instances to uniquely identify any particular well. Commonly, consultants and other groundwater practitioners will provide a borehole record independent of the well driller. Trying to match the MOE record (as received from the driller) with the consultant produced record (which often contains enhanced details above what the driller reports to the MOE) often can be difficult. One suggestion that might assist in this regard is to provide the opportunity to name a well on the well record form. It should be noted that access to the original well record form via the web is currently being planned by the MOE and it is recognized that this will help to resolve this issue into the future since then the "A-tag" number and the "Audit" number will then be available.

4.3 Incorporation of Temporal Data

One important area where the current WWIS database could be improved is in its ability to effectively capture and store long term groundwater related measurements over time. The WWIS database has been designed to store the few water level measurements collected at each well during initial testing, however longer term pumping rates, chemistry data or additional water level data have no home within the WWIS.

Effective groundwater resource management requires access to the historical measurements. Water quality or water level trends, when measured over long time periods ensure understanding of the groundwater system (e.g. how the system might respond to climate change, droughts and wet conditions, how land uses might be affecting quality, etc.).

The YPDT-CAMC database has been established to store temporal data that is tied back to a particular screened interval in a well. Within the database, reading name codes that point to specific parameters can be diverse, ranging from climate related codes (e.g., precipitation, temperature, etc.) to water quality related codes (e.g., chloride, pH, BTEX, etc.) to hydraulic related parameters (e.g., water level, pumping rate, streamflow, etc.). Such a transformation in the WWIS would bring it closer to a more comprehensive groundwater management system database.

4.4 Incorporation of subsurface geological framework

As part of a longer term groundwater knowledge management infrastructure there is a growing need to establish common geological frameworks, particularly in areas of thicker glacial sediment packages. Such a framework can be used into the future to gain an improved understanding of the subsurface environment. Across Ontario this is being driven by the fact that groundwater flow modelling is becoming a more mainstream investigative tool. Although the WWIS does a good job of documenting and providing the individual layers encountered as wells are being drilled, it falls short in terms of moving forward to interpret individual layers as part of a recognized geological formation or unit that can guide future geoscientists. Perhaps the geological and

hydrogeological interpretations being prepared for the Source Water Protection program by watershed (Conservation Authority jurisdiction) could be amalgamated into a Province-wide interpretation leading to the publishing of updated aquifer mapping.

By providing an integrated table of interpreted geological picks (as well as the "kriged" or synthetic geological contacts at wells that have not been picked) hydrogeologists utilizing the YPDT-CAMC database have access to a number of geological interpretations that have been made over the years, providing a context from which they can plan projects for their newer clients. The geological materials encountered while drilling through these recognized geological formations or units can then be analysed on a formation by formation basis to look at the variability of subsurface units that control groundwater movement.

4.5 Integration of Other Datasets.

In addition to attaching temporal data to the individual wells in the WWIS database, there are other opportunities to expand on the Province's water management system by connecting the WWIS with other datasets. First and foremost of these should be the Permit to Take Water (PTTW) database. Certainly from the perspective of sound groundwater management, having the water well records tied to the permit database would allow water managers to evaluate the amount of water currently allocated in a given area. If coupled with the proposed improvements as noted above, this would, for the first time in Ontario allow the province to look across broad areas and to assess the amount of groundwater allocated by aquifer. Certainly a worthwhile goal as it relates to comprehensive groundwater management.

Another opportunity that has been identified, is the linking of the well records with key reports that are submitted to the Province in support of various land use planning initiatives. The longer term goal would be to provide hydrogeologists with access to publicly available historical technical groundwater reports in a PDF format. The amount of consulting time allocated to searching for background information across the province would be drastically reduced.

5 SUMMARY

In south-central Ontario the WWIS database has evolved from its solid roots in the Ministry of the Environment to become a dynamic, actively managed integral component of a comprehensive groundwater management program. It has been proposed that improvements can and should be made to the existing WWIS system to enable Ontario to rightfully claim its role as a global water leader.

6 REFERENCES

YPDT-CAMC, 2006. *Database Manual.* Internal Program Report.