University of Toledo College of Law

Legal Institute of the Great Lakes

LakeLinks

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A multi-disciplinary forum for dialogue and expression of diverse viewpoints on issues of importance to the Great Lakes region

Special Points of Interest

National Water Crisis:

GROUNDWATER CONFERENCE

NOVEMBER 14 , 2003

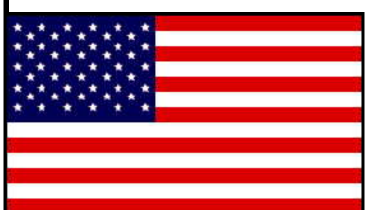
University of Toledo College of Law

See Inside….

A Brief Guide to U.S. Groundwater Law *

By Mark Squillace , Professor, University of Toledo College of Law

Groundwater law in the United States began with a bow to ignorance. An old English case, *Acton v. Blundell*, 152 Eng. Rep. 1228 (Ex Chamber, 1843), from which early American law developed, noted for example, that "no man can tell what changes these under-ground sources have undergone in the progress of time…and no proprietor knows what proportion of water is taken from beneath his soil: how much he gives originally, or how much he transmits only, or how much he receives…." Ignorance about the occurrence of groundwater led the English court to adopt a "rule of capture," whereby a landowner may take water from beneath her property and use as much of that water as she can profitably take, even where such extractions cause injury to others.



This "English Rule" of absolute ownership did not generally cause significant conflicts among water users so long as groundwater was extracted by low technology devices such as hand pumps, or pumps run by windmills. But the invention of the high speed centrifugal pump in 1937 made possible the extraction of large quantities of groundwater quickly, and thereby setting the stage for conflicts among groundwater users. Significant groundwater extractions lower water tables, and draw down aquifers, thereby increasing the likelihood of conflict among groundwater users. In some circumstances, groundwater extraction also results

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Groundwater Management in Ontario: A Brief Summary of Law & Policy

By Ramani Nadarajah, counsel, Canadian Environmental Law Association

Groundwater is a vital source of drinking water for approximately three million Ontarians. Nearly ninety percent of residents in rural Ontario rely on groundwater as their source of drinking water. Groundwater is also an important water source for agricultural, commercial and industrial operations.

Prior to 1961, groundwater takings in Ontario were unregulated. A permit system was established on March 29, 1961 via amendments to the *Ontario Water Resources Act* ("*OWRA*"). The *OWRA* requires anyone withdrawing water in excess of 50,000 litres per day to obtain a Permit to Take Water ("PTTW"). However, takings for domestic, farm or fire fighting purposes are exempt under the Act. In addition, permits are not required for takings that existed before the establishment of the permit system.

Although people withdrawing less than 50,000 litres per day do not normally require a permit, they can be required to get one if their taking causes any groundwater interference problems. This also applies to water users whose takings predate March 29, 1961. If a new groundwater taking interferes with another water supply that was in use prior to the issuance of the new permit, the permittee is required to restore the supply or reduce the taking to eliminate the

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An Introduction to *LakeLinks* Fall 2003

Professor Frank Merritt, Chair, Faculty Management Committee of *LakeLinks*

The Great Lakes contain approximately twenty percent of the world's fresh water. As such they constitute an incomparable resource for this region of the United States. The Great Lakes have been studied for many years and the basic hydrology of the lakes is reasonably well understood. In contrast, the ground water resources of the basin have only recently been studied as a system and the interrelation between ground water and the Lakes is yet to be fully appreciated. It is now reasonably well understood that the ground water aquifers within the Great Lakes Basin are not coterminous with the limits of the surface drainage basin. There is a carbonate aquifer that appears to connect Lake Erie and Lake St. Clair with Lake Michigan and the Ohio River and a Sandstone aquifer that appears to connect Lake Michigan with the Mississippi and Missouri rivers.[i] Neither the present flow nor the historic flows are certain, but it is known that ground water levels above lake levels suggest that ground water will be added to the lakes while ground water levels below the lake levels suggests that the lakes will supply some water to the aquifer. Historical data suggests that aquifer water level in Chicago was some 130 feet above Lake level. By 1980 this level has dropped 900 feet in Chicago .[ii] The effect of this was to degrade the quality of the water which in turn reduced pumping and caused the water level to raise some 250 feet.

This issue of ***LakeLinks*** is intended to provide the reader, be she neophyte or specialist, with a brief overview of groundwater law and information resources in the Great Lakes area and is published in conjunction with the College of Law and Legal Institute's program on ground water being held on November 14th.

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[i] N. Grannemann, R. Hunt, J. Nicholas, T. Reilly and T. Winter: The Importance of Groundwater in the Great Lakes Region (2002) (U.S.G.S.) p. 2, figures B & C.
[ii] Id at 7.

Frank Merritt with long-time friend Smokey the Bear

(U.S. Groundwater Continued from page 1)

in land subsidence, which can damage structures on the surface as well as the reducing the long-term storage capacity of the aquifer itself. In addition to these potential problems, the English rule promotes a destructive race to the bottom of the aquifer. Nonetheless, the English rule has been followed in a number of American states including Connecticut, Indiana, Louisiana, Maine, Massachusetts, Mississippi, Rhode Island, and Texas.

Even accepting ignorance about the occurrence of groundwater, many American states concluded that the potential for mischief under the English rule was too great, and substituted instead their own rule. The American rule of "reasonable use" is not as limiting as its descriptor might suggest but it does avoid some of the worst conflicts that arise under the English rule. Like the English rule, the American rule operates essentially as a "rule of capture." A landowner may extract water from under her property and use that water on the surface without regard to injuries to others. Unlike the English rule, however, landowners operating under the American rule may only use their water on the surface of their own land, unless sufficient water is available to use on other lands without causing injury to others. The American rule thus offers a kind of rough equity by limiting the potential for groundwater use to the tract of land owned by the extractor.

Despite this important limitation, the American rule can still lead to conflicts, especially where groundwater is used to irrigate crops. Irrigated agriculture is by far the largest user of water resources throughout the United States regardless of the source, and when vast quantities of groundwater are extracted to grow crops, conflicts are common. Still, the American rule, at least in part, is followed in about 19 states including Alabama, Arizona, Arkansas, Deleware, Florida, Georgia, Illinois, Kentucky, Maryland, Missouri, New Hampshire, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia.

The problems associated with a "rule of capture" led some states to opt for a system that promotes equitable sharing of groundwater resources. The oldest and most common rule for sharing groundwater resources is the correlative rights doctrine, which was first articulated by the California Supreme Court in *Katz v. Walkinshaw*, 141 Cal. 116, 74 P. 766 (1903). Under the correlative rights rule, landowners are entitled to use groundwater on the surface of their own lands so long as they do not unreasonably impair the rights of other landowners to do the same. If there are insufficient groundwater resources available for all landowners to use on their own lands then they must share their water, much as water is shared under the common law riparian doctrine for surface water resources. Groundwater can be taken to other lands, only if sufficient water is available to satisfy all of the reasonable needs on the overlying land. Seven states have suggested a preference for the correlative rights doctrine. These include: California, Hawaii, Iowa, Minnesota, Nebraska, New Jersey, and Vermont.

A similar but somewhat more flexible doctrine is established under the Restatement of Torts, 2d, § 858. The Restatement rule allows landowners to extract groundwater from under their property and use it anywhere they please, but they

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are subject to liability to other landowners if their uses of the withdrawal – (1) causes unreasonable harm to neighboring land because of lowering of the water table or reduction in artesian pressure; (2) exceeds the landowner's reasonable share; or (3) causes a direct and substantial impact on a watercourse and unreasonable harm to a person entitled to use the watercourse. Unlike the correlative rights rule, the Restatement does not restrict the place of use of groundwater.

The chief objection to the Restatement rule is that it requires a showing of harm before it can be invoked. As a result, a person desiring to use groundwater may incur considerable expense in drilling a well only to find out thereafter that her use will be enjoined because it causes "unreasonable" harm. Three prominent Great Lakes states follow the Restatement rule. They are Michigan, Ohio and Wisconsin.

Finally, some Western states that follow the prior appropriation doctrine for their surface water, follow the same rule for groundwater. Thus, the first person to apply for and obtain a permit to use groundwater has a better right than subsequent users within the same aquifer. As applied to groundwater, however, the prior appropriation doctrine operates somewhat differently than it does with respect to surface water. These differences stem largely from the fact that unlike most of the surface water resources of the Western states, groundwater flows do not vary dramatically with the season, and the amount of recharge is generally much smaller than with surface water. To accommodate these differences, most Western states have a policy of maximizing the beneficial use of their groundwater resources. This means that subsequent groundwater permittees are allowed to reduce the water pressure of more senior users if such reductions will help maximize the utility of groundwater resources. They may even be allowed to pump water at rates that cause some senior wells to run dry if the State finds that the senior well was not drilled to a sufficient depth to promote the maximum use of the water.

Moreover, many Western states allow groundwater mining, which results when more water is taken from an aquifer than it receives through recharge. Mining will eventually result in the depletion, and over the long-term, the loss of the aquifer. While this harms the senior appropriator it is nonetheless accepted practice in some prior appropriation States. The thirteen states with a general preference for prior appropriation for their groundwater include Alaska, Colorado, Idaho, Kansas, New Mexico, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

While groundwater law remains important, many states are moving toward managing their surface and ground water resources as a unitary system. "Conjunctive use" is a term that is used to describe efforts by some states to optimize the beneficial use of their surface and ground water resources by recognizing their hydrologic connection. Many prior appropriation states, for example, treat groundwater that is directly connected to surface water, as "tributary groundwater" which must be managed as part of the surface water system. More recently, states have begun to recognize that some large groundwater basins are supporting more limited surface water supplies. By encouraging and perhaps even requiring surface water users to shift their point of diversion from a surface water diversion to a groundwater well, many more water users can sometimes be accommodated without harming the overall water resources of the basin. *See e.g., Alamosa-La Jara Water Users Protect. Ass'n v. Gould,* 674 P.2d 914

(U.S. Groundwater continued on page 4)

Credit: U.S. Geological Survey, General Interest Publication, Reston Virginia. http://capp.water.usgs.gov/GIP/gw_gip/index.html

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(Colo. 1983).

In areas like the Great Lakes basin, where you are never very far from a stream or a lake, most groundwater systems are directly connected to surface water systems. Consequently, groundwater withdrawals will almost always cause direct impacts on surface water resources. Recognition of this fact should lead these states to begin managing their water resources under a single legal system that promotes optimizing the beneficial use of water while assuring adequate protecting for amenity values. Providing incentives for surface and groundwater water users to divert their water from or near the vast water resources of the Great Lakes themselves, for example, would likely avoid most of the water resource conflicts and problems that currently arise there.

* Citations taken from: *Who Owns the Water: A Summary of Existing Water Rights Law*, Water Systems Council, 2003.
Ind. Code Ann. § 14-25-7 (Michie 1998)
[2] Illinois Compiled Statutes Chapter 525. Conservation Act 45. Water Use Act Of 1983 45/3.
[3] Forbell v. City of N.Y., 164 N.Y. 522 (N.Y. 1900).
[4] Rothrauff v. Sinking Spring Water Co., 339 Pa. 129, 14 A.2d 87 (Pa. 1940).
[5] Erickson v. Crookston Waterworks, Power & Light Co., 111 N. W. 391 (Minn. 1907).
[6] Maerz v. United States Steel Corp., 116 Mich. Ct. App. 710, 323 N.W.2d 524 (Mich. Ct. App. 1982).
[7] Ohio Rev. Code § 1521.17.
[8] State v. Michels Pipeline Constr. Inc., 63 Wis. 2d 278, 217 N.W.2d 339 (Wis. 1974). ■

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interference. The permit program is thus designed to provide protection to prior users of groundwater, a protection not generally afforded by the common law.

Since the early 70's, water management policy in Ontario has required the Director of the Ministry of Environment ("MoE") to consider an application for a PTTW in light of the information concerning the availability of water supply, the use to which the water is put, and the effects that the proposed taking would have on other users, prior to authorizing any increase in taking. However, historically, PTTWs have been issued on a first come first served basis, without consideration of the impacts the water taking would have on a watershed.

Furthermore, there have been no requirements for permit holders to report the actual amount of water taken. Nor does the MoE have a complete inventory of surface and groundwater resources by watershed, except in a few areas where municipalities have undertaken in-depth studies. Consequently, the Ministry often does not have an accurate picture of the state of the resource or the cumulative impacts of water takings.

In recent years there has been increasing concern amongst the public about the scale and number of water takings in Ontario and more intense competition amongst users, including farmers, for access to groundwater supply. This has been problematic since groundwater is often the primary source of rural water supply in the Province, particularly in southern Ontario and constitutes a significant component of streamflow, particularly during times of dry weather.

The 1996 Annual Report by the Provincial Auditor highlighted serious gaps in groundwater monitoring by MoE. The following year, Ontario's Environmental Commissioner also raised serious concerns about the lack of a comprehensive provincial strategy to protect and manage groundwater.

This situation compelled the government to action to address a number of key weaknesses in the legislative framework governing groundwater. In April 1999, the government passed Regulation 285/99 Water Taking and Transfer Regulation, in response to the concerns raised by the Environmental Commissioner and the Provincial Auditor regarding the lack of adequate protection of Ontario's groundwater. The regulation marked the first major legislative initiative to manage the water resources of the Province since the establishment of the permit system in the 1960s. The regulation required the Director to consider the impact that proposed water taking would have on the natural functions of the ecosystem, prior to issuing a PTTW. The Director may also consider the impact that a water taking would have on future agricultural, livestock and municipal sewage and water use, and determine whether it is in the public interest to grant the permit. In addition, the Director is required to consider the interests of other users before making any water allocation.

In May 2000, the municipal water system in Walkerton, Ontario became contaminated with the deadly bacteria, E-Coli (*Escherichia coli* O157:H7) and *Campylobacter jejuni*. The contamination was caused by manure that had been spread on a farm and infiltrated into groundwater, the source of Walkerton's drinking water supply. As a result of the contamination, seven people died and more than 2,300 people became ill. This event focused unprecedented attention on groundwater issues in Ontario.

In the wake of the Walkerton Tragedy, the Ontario Government established a Public Inquiry, headed by the Honourable Mr. Justice Dennis O'Connor, to investigate the cause of the contamination and to make recommendations to protect the safety of drinking water in the province. Mr. Justice O'Connor's report contains extensive recommendations for source water protection, including groundwater. One of the key recommendations in Mr. Justice O'Connor's report

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Groundwater Resources and Hydrogeology of the Maumee River Drainage Basin

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While the Great Lakes contain approximately 20% of the world's fresh surface water, groundwater reservoirs represent an equally plentiful and vital water resource. Within this fresh-water system the Maumee River drainage basin is the largest basin contributing to the Great Lakes from a single river. The 6,600 mi^2 basin covers much of northwest Ohio, the Fort Wayne region of northeastern Indiana and Hillsdale County of central southern Michigan. The Maumee Basin is predominantly agricultural but also contains moderately large urban centers including Toledo and Lima, Ohio and Fort Wayne, Indiana. The diversity of populations and geology provides valuable examples of water resource usage and hydrogeology in the Great Lakes Basin as a whole.

Publicly supplied water of urban northwest Ohio is largely drawn from surface water. For example, Toledo withdraws approximately 70 million gallons a day (MGD) from Lake Erie and Bowling Green withdraws 5 MGD from the Maumee River. However, the rest of northwest Ohio, which is predominantly rural, extracts approximately 60 MGD of groundwater as the primary water resource as shown in Table 1 (Breen and Dumouchelle 1991; Solley et al. 1998). Quality and contamination of surface water receives close scrutiny in part because streams are important for water supply and recreation and in part because they are vulnerable to direct contamination. Although depletion and contamination of groundwater resources are less obvious, the issues are no less important. In effect, the pathways of recharge and contamination of aquifers in northwest Ohio have been paid less attention due to the complexities and remoteness from common experience, an attitude evident in early Ohio (Frazier 1861) which persists today. Two common threats that call attention to these inconspicuous groundwater resources are dropping water levels that cause wells to go dry (e.g., Cline 1984) and contaminant sources that pose health risks. A thorough understanding of these water quantity and water quality issues requires an understanding of the pathways that provide the groundwater reservoirs with recharge and, consequently, transport contaminants to the subsurface (Martin-Hayden et al. 1999). These pathways are controlled by soil and bedrock characteristics such as permeability to flow of water, distributions and thicknesses.

Table 1: Water use in the Maumee River Watershed (Based on Data from Solley et al. 1998).

Category of Use	Withdrawals: Total Fresh Water (MGD)	Withdrawals: Percent Groundwater	Withdrawals: Groundwater (MGD)	Public Supplies: Total (MGD)	Public Supplies: Groundwater (MGD)
Public Supply	59.8	21.5%	12.9	---	---
Domestic	13.4	98.0	13.1	20.9	4.5
Commercial	17.7	32.1	5.7	29.9	6.4
Mining	7.6	88.6	6.8	0.0	0.0
Agriculture	4.1	34.5	1.4	0.0	0.0
Totals	102.7	38.8%	39.9	50.8	11.0

The Maumee Bay Watershed includes the Maumee River and Cedar-Portage drainage basins.
Fresh water withdrawals from surface water and groundwater.
Percent of fresh water withdrawals that are groundwater. (The remainder is surface water)
Water supplied from public supply withdrawals.
Public supplies of water are predominantly withdrawn from surface water.
Commercial withdrawals are 80% industrial use and 11% thermoelectric use.
Agriculture includes 59% irrigation and 41% livestock use.

Groundwater recharge typically occurs where permeable water-bearing units (aquifers) are exposed to direct infiltration at the surface (see Figure 1) or where ample leakage is supplied to deeper aquifers from overlying units. In the Maumee River basin the major aquifer is predominantly a thick unit of fractured limestone-like dolomite often referred to as the carbonate aquifer (Andreus 1996; Breen and Dumouchelle 1991; Bugliosi 1990). The Maumee Basin is located on the western limb of the Findlay Arch, a broad up-warping of the carbonates which exposes the aquifer along the axis of the arch (Figure 1). The carbonate aquifer is covered by impermeable shale, a relatively impermeable rock that confines the

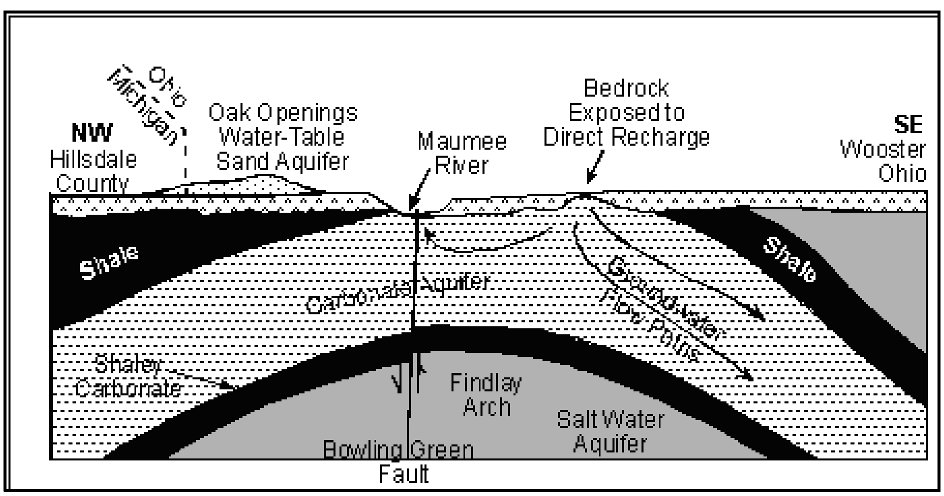

Figure 1

(Hydrogeology Continued from page 5)

groundwater flow within the dolomite unit. Before the last glaciation (10-20 thousand yeas ago) the bedrock was incised by the ancestral Maumee River system which left a valley nearby and parallel to the present Maumee River Valley (Bush 1966). The glaciers that advanced over the area plastered over the ancestral drainage system with a low-permeability clay-rich glacial till. This glacial till confines flow within the carbonate aquifer where the shale is absent. However, direct recharge to the carbonate aquifer occurs where bedrock ridges poke up through the relatively flat topography of the glacial till as shown to the right of center on Figure 1. These areas of exposed bedrock comprise less than 2% of the carbonate aquifer and hence account for a small percentage of the carbonate-aquifer recharge (Martin-Hayden et al. 1999). Much of the recharge occurs as a result of slow but widespread leakage through the glacial till to areas where the carbonate aquifer is not confined by shale.

Another notable type of aquifer in the Maumee River Basin is comprised of a layer of sand that was deposited as beach ridges by glacial lakes between 10,000 and 8,000 years ago (e.g., the Oak Openings Water Table Aquifer of Lucas County, Ohio). This shallow water-table aquifer is used for self supplied domestic water use and small scale irrigation. Finally, an aquifer that supplies half of the public supply withdrawals in the Maumee River Basin is located beneath Williams County in the far northwest corner of Ohio. In this region a thick layer of glacial till is comprised of sands and gravels and is confined by clayey glacial till. These three types of aquifers, confined fractured-bedrock aquifers, water-table sand aquifers, and confined sand and gravel aquifers, are representative of the types of aquifers found throughout the Great Lakes Basin. By investigating the relative importance of groundwater resource usage, it becomes evident that groundwater represents a crucial resource that is as important as the highly scrutinized surface-water resources.

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Andreus ES. 1996. Groundwater recharge to the semiconfined carbonate aquifer near whitehouse, Ohio [Master of Science Thesis]. Toledo, Ohio: University of Toledo. 119 p.

Breen KJ, Dumouchelle DH. 1991. Geohydrology and quality of water in aquifers in Lucas, Sandusky and Wood Counties, northwestern Ohio. Columbus, Ohio: U.S. Geological Survey. Report nr 91-4024.

Bugliosi EF. 1990. Plan of study for the Ohio-Indiana carbonate-bedrock and glacial-aquifer system. : U.S. Geological Survey. Report nr 90-0151.

Bush AE. 1966. Drift thickness and bedrock topography of the Toledo Aarea [Master of Science Thesis]. Bowling Green, Ohio Bowling Green State University. 24 p.

Cline V. American Aggregates. 1884. 15 Ohio St. 3rd, 474, NE.2d.

deRoche JT, Breen KJ. 1989. Hydrogeology and water quality near a solid- and hazardous-waste landfill, northwood, Ohio. Columbus, Ohio: U.S. Geological Survey. Report nr 88-4093.

Frazier V. Brown. 1861. 12 Ohio St. 294.

Martin-Hayden, J.M., R.J. Minarovic, E.S. Andreus, and S.L Kozak. Carbonate aquifer recharge in western Lucas County, northwest Ohio. *The Ohio Journal of Science*, v.99, no. 4., December 1999.

Solley, WB, Pierce, RR, and Perlman, HA. 1998. Estimated Use of Water in the United States in 1995. US Geological Survey, Denver olorado, Circular 1200, 66 pg.

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(ONT Groundwater continued from page 4)

was that water budgets be prepared on a watershed basis in order to assess the cumulative impacts of water takings on the sustainability of water resources.

Subsequently, in April of 2003, the government proposed further amendments to Regulation 285/99 in response to urgings by the Association of Municipalities of Ontario, the Environmental Commissioner's Office, the Conservation Authorities and the Environmental Review Tribunal that the MoE update its PTTW program. The proposed regulation would require:

- new applicants for a PTTW to notify municipalities, conservation authorities and adjacent landowners about proposed water takings;
- require reporting of water use by permit holders; and
- define potential impacts that will be considered when reviewing a permit application.

The amendments, if adopted, would mark a positive step and would considerably improve the protection of groundwater under the PTTW program. The MoE has also taken the initiative to improve monitoring of groundwater and surface water. This has included the completion of a three-year project to establish a provincial groundwater-monitoring network in cooperation with conservation authorities.

However, additional reforms are required to ensure the effective protection and management of Ontario's groundwater. The MoE still does not have any defined criteria for assessing the impact that a water taking will have on the ecosystem as mandated by Regulation 285/99, and is thus unable to assess the cumulative impacts that PTTWs would have on a subwatershed or watershed. With a few exceptions, the Ministry does not have water budgets for watersheds, to allow it to assess whether the total amount of water allocated under PTTWs is sustainable. These factors, coupled with the lack of a coherent overall strategy for protecting Ontario's groundwater, suggest that much remains to be done.

Nearly six years ago, the Environmental Commissioner of Ontario recommended that the MoE develop and implement a groundwater protection and management strategy for Ontario. Some of the key elements of the Commissioner's recommendation were:

- a publicly accessible inventory of groundwater resources and data management system;
- a long-term monitoring network of water levels for major aquifer systems;
- a system to identify and protect sensitive aquifers and groundwater;
- an inventory of current and past uses of groundwater and sources of groundwater contamination and an evaluation of their potential effect on health and ecosystems, including cumulative impacts; and
- a strong regulatory program aimed at preventing contamination.

These recommendations, many of which have not yet been adopted, would go a long way towards ensuring the wise use and management of a precious resource for the benefit of present and future generations of Ontarians.

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FYI

Insightful Sources for Information on Groundwater Resources

David J. Allee, Leonard B. Dworsky and Albert E. Utton, *The Great Lakes: Transboundary Issues for the Mid-90s*, 26 U. Tol. L. Rev. 347, (WINTER 1995).
Summary: this article outlines the history of North American transboundary water issues, focusing on two North American boundary commissions: the International Joint Commission (IJC) established by the United States and Canada and the International Boundary and Water Commission (IBWC) formed by the United States and Mexico. Also see: Sanford E. Gaines, *Fresh Water: Environment or Trade*, 28 Can.-U.S. L.J. 157 (2002).

Brian D. Anderson, *Selling Great Lakes Water to a Thirsty World: Legal, Policy & Trade Considerations*, 6 Buff. Envt'l. L.J. 215, (Spring 1999).
Summary: this article looks at Alaska's water export statutes as a useful guide in regulating future sales of Great Lakes waters, while still protecting the environment.

Leticia M. Diaz and Barry Hart Dubner, *The Necessity of Preventing Unilateral Responses to Water Scarcity—The Next Major Threat Against Mankind this Century*, Cardozo J. Int'l & Comp. L. 1, (Spring 2001).
Summary: this article gives a general overview of the Great Lakes basin and some of the issues concerning the lakes, including: governing statutes and commissions, ownership of fresh water, groundwater pumping, and the environmental consequences of urban sprawl.

Mark J. Dinsmore, *Like a Mirage in the Desert: Great Lakes Waterquantity Preservation Efforts and Their Punitive Effects*, 24 U. Tol. L. Rev. 449, (Winter 1993).
Summary: analysis of the approach to Great Lakes water quantity preservation, which considers the possible dangers of both diversions and consumptive uses while discussing important case law on the designation of water as an item of commerce and on international policy concerning the fundamental principles defined and eloquently set out in the Great Lakes Charter.

Dylan O. Drummond, *Texas Groundwater Law in the Twenty-First Century: A Compendium of Historical Approaches, Current Problems, and Future Solutions Focusing on the High Plains Aquifer and the Panhandle*, 4 Tex. Tech J. Tex. Admin. L. 173, (2003).
Summary: an all-inclusive exposition concerning the legal ramifications and scientific implications relating to the history and present condition of the allocation and private marketing of groundwater among the ever-demanding populace of Texas.

Christine Elwell, *NAFTA Effects on Water: Testing for NAFTA Effects in the Great Lakes Basin*, Tol. J. Great Lakes' L. Sci. & Pol'y 151, (Spring 2001).
Summary: this article assesses the effects of NAFTA on the water in the Great Lakes Basin by looking at 3 main areas: bulk water exports and use, privatization of water services and water quality, especially related to the growth of non-point source pollution.

Kenneth A. Hodson, *The Dormant Commerce Clause and the Constitutionality of Intrastate Groundwater Management Programs*, 62 Tex. L. Rev. 537, (1983). Summary: this article discusses current groundwater problems by looking at the Arizona system and assessing the permissible limits for state regulation of groundwater production after the Supreme Court decision in *Sporhas v. Nebraska ex rel. Douglas*. Also see: Edward B. Schwartz, *Water as an Article of Commerce: State Embargoes Spring a Leak Under Sporhase v. Nebraska*, 12 B.C. Envtl. Aff. L. Rev. 103, (Fall 1985).

Eric Opiela et al., *The Rule of Capture in Texas: An Outdated Principle Beyond its Time*, 6 U. Denv. Water L. Rev. 87, (Fall 2002).
Summary: this article discusses the rule of capture, using Texas as a case study, and compare two distinct definitions of the rule of capture: as a use of groundwater for which no cause of action in tort, and as a vested property right of absolute ownership.

Erik Swenson, *Public Trust Doctrine and Groundwater Rights*, 53 U. Miami L. Rev. 363, (1999).

Summary: argues that the public-trust doctrine, the purpose of which is to protect certain natural resources for public use, should encompass groundwater rights. This article contains a very good overview of the complex nature of groundwater flow, and the different systems that states have implemented to allocate the resource.

Dan Tarlock, *Reconnecting Property Rights to Watersheds*, 25 Wm. & Mary Envtl. L. & Pol'y Rev. 69, (Fall 2000).
Summary: this article examines the extent to which common law property rights use watershed resources to promote watershed conservation.

Tara Boldt-Van Rooy, *"Bottling Up" Our Natural Resources: The Fight Over Bottled Water Extraction in the United States*, 18 J. Land Use & Envtl. Law 267, (2003).
Summary: the issue presented by this Note is whether states need to develop stricter laws to protect the quantity of their fresh water resources from the expansion of the bottled water industry.

Sandra B. Zellmer and Scott A. Johnson, *Biodiversity in and Around Mcelligot's Pool*, 38 Idaho L. Rev. 473, (2002).
Summary: this essay argues that farmland preservation is worthwhile from a biodiversity standpoint, and offers a few preliminary suggestions for addressing why.

Websites

http://water.usgs.gov/nwis/gw
The Ground-Water database contains ground-water site inventory, ground-water level data, and water-quality data. The inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States.

http://www.epa.state.oh.us/ddagw/
The Ohio Environmental Protection Agency, Division of Drinking & Ground Waters site provides information about Ohio rules and regulations affecting ground water in Ohio.

http://ohioline.osu.edu/lines/ennr.html
The Ohio State University College of Food, Agriculture and Environmental Science site provides links to information on Ohio groundwater resources, including a summary and explanation of the ground water aquifers underlying most counties in Ohio.

http://capp.water.usgs.gov/gwa/ch_k/
The United States Geological Survey Ground Water Atlas provides maps of the Central Lowland aquifers, Interior Low Plateaus aquifers, Appalachian Plateaus aquifers, Valley and Ridge aquifers, Blue Ridge aquifers, Ozark Plateaus aquifers, Southeastern Coastal Plain aquifers and the Mississippi Embayment aquifer system.

http://www.great-lakes.net/envt/water/ground.html
The Great Lakes Information Network site provides materials on understanding the importance of groundwater, reports on trends in groundwater levels and links to other useful resources.

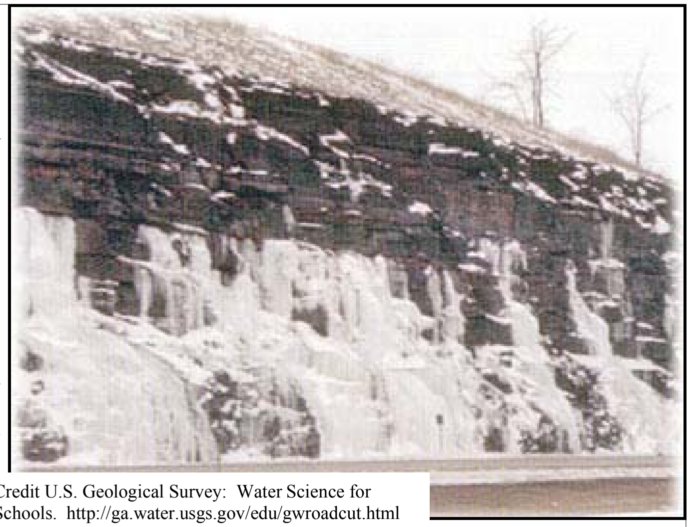
http://www.greatlakesdirectory.org/great_lakes_water_export.htm
The Great Lakes Directory site provides links to numerous articles on a variety of Great Lakes water issues including diversions from the Great Lakes and depletion of ground water in the Great Lakes region.

http://water.usgs.gov/ogw/pubs/WRI004008/
This United States Geological Survey site contains information on the importance of ground water in the Great Lakes region and how it works, including specific data on the effects ground water pumping has had in particular regions.

http://www.nemw.org/glwater_divert.htm
The Northeast-Midwest Institute page on Great Lakes Water Diversions provides summaries of how each Great Lake state handles basin water withdrawals as well as a summary of Annex 2001. It also provides links to other sites providing information regarding diversions from the Great Lakes.

http://mi.waterdata.usgs.gov/siglissues.php
This United States Geological Survey site provides information on ground water flow to the Great Lakes, effects of land use on water quality and more.

http://www.sws.uiuc.edu/gws/
The Illinois State Water Survey, Groundwater Section site provides information on the Mahomet Aquifer, which is the major groundwater resource for east-central Illinois. It also provides a study regarding arsenic in Illinois groundwater, with links to information of the problem of arsenic levels in United States groundwater generally. There are also articles on the future demands on Illinois groundwater and ongoing research projects.



Credit U.S. Geological Survey: Water Science for Schools. http://ga.water.usgs.gov/edu/gwroadcut.html

http://www.michigan.gov/deq/0,1607,7-135-3313_21698---,00.html
The Michigan Department of Environmental Quality website provides numerous links to their groundwater modeling program. There are also links for Michigan laws and rules pertaining to groundwater and information on the problem of discharge of pollutants into groundwater.

http://www.in.gov/dnr/water/ground_water/index.html
The Indiana Department of Natural Resources, Water Division website contains groundwater assessment maps for Boone County and Hendricks County, a groundwater availability map, and information on the hydrology of the Lafayette Bedrock Valley System. There are also links to Indiana rules and regulations pertaining to groundwater.

http://www.pca.state.mn.us/water/groundwater/index.html
The Minnesota Pollution Control Agency: Ground Water in Minnesota site provides numerous links to information on how groundwater works and why we should be concerned about it as well as links to groundwater publications, data and programs.

http://www.dnr.state.wi.us/org/water/dwg/gw/index.htm
The Wisconsin Department of Natural Resources: Ground Water site contains a listing of resources and programs for Ground Water in Wisconsin.

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