Briefing Paper:
Summary of Current Water Conservation Practices in the Public Water Supply Sector of the Great Lakes-St. Lawrence Region

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Preface

This briefing paper is one of three products developed through the project, *Developing Water Conservation "Tool Kit" in the Great Lakes Region*, supported by the Great Lakes Protection Fund and authored by the Great Lakes Commission. The objective was to assess the state of water conservation within the Great Lakes region. In so doing, it informs the work of the Great Lakes states and provinces in implementing the 2001 Annex of the Great Lakes Charter of 1985. This project particularly addresses the Annex provision to establish a decisionmaking standard based on the principle of "preventing or minimizing Basin water loss through return flow and implementation of environmentally sound and economically feasible water conservation measures."

The Commission's involvement in this project reflects its long-term interest in Great Lakes water resources management activities consistent with its mandate to "promote the orderly, integrated and comprehensive development, use and conservation of the water resources of the Great Lakes basin" (Article I, Great Lakes Basin Compact). The principle author of this paper is Rebecca Lameka, Great Lakes Commission, Program Specialist. Ongoing project consultation and oversight has been provided by a project advisory committee comprised of representatives from federal, state and provincial government and other interested groups. This briefing paper has benefitted from the significant input and collaboration of the members of this group. The membership list is included in Appendix E.

The Commission also extends its appreciation to the Project Advisory Committee, Council of Great Lakes Governors and its Annex 2001 Working Group, and the staff of the Great Lakes Protection Fund for the guidance, input and support throughout the project.

Executive Summary

This report is one of several products being developed by the Great Lakes Commission under a project titled: *Developing Water Conservation "Tool Kit" in the Great Lakes Region.* The project is supported by the Great Lakes Protection Fund of Evanston, Illinois and is one of a suite projects supported by the Protection Fund to guide and inform the Great Lakes states and provinces as they begin to implement the provisions of the 2001 Annex of the Great Lakes Charter of 1985. The purpose of this briefing paper is to provide a greater understanding of the current state of water conservation practices in the public water supply sector in the Great Lakes region. To evaluate the state of water conservation efforts in the region, a survey of public water suppliers was developed and administered in March 2003. A randomly selected group of 525 municipal water supply facilities were surveyed from a larger set of 1,828 facilities. Surveys were mailed to the selected facilities to gather information about water conservation practices implemented in their service areas. More than 25 percent (136) of the facilities surveyed participated in the summary with responses coming from Illinois, Michigan, Minnesota, New York, Pennsylvania, Ohio, Ontario and Québec. The survey results provided a sample of conservation activities across the region and among different community sizes. Topics covered by the survey included water conservation activities, formal conservation plans, financial incentives, guidelines, regulations, future trends in conservation activities and education. A few trends in the responses to the survey are worth noting.

- Meter calibration and replacement and leak detection and repair are among the most practiced conservation activities by water systems surveyed in the Great Lakes region.

- The least practiced conservation activities include subsidizing low-flow plumbing fixtures and the application of inverted pricing blocks for water rates.

- More than half (65%) of the facilities who responded do not operate under any formal conservation plan.

- Education programs exist within less than half of the facilities (48%) responding. Bill inserts seem to be the preferred approach to consumer education.

Listed below is a more detailed account of concluding observations gleaned from the survey and grouped by topical categories.

Conservation Planning and Regulations

- The federal policies and initiatives administered through the U.S. Environmental Protection Agency and Environment Canada may provide opportunities to apply conservation programs in the Great Lakes region.
- Nearly half of the Great Lakes jurisdictions do promote water conservation through various programs; the most effective programs appear to be those that marry conservation requirements to permitting.

- In general, conservation efforts among local jurisdictions are few; the lack of conservation efforts can be primarily attributed to the perception of adequate or abundant water supplies from all sources of water.
- An accurate assessment of water supplies along with a commitment to conducting forecasts of future water demand may help local municipalities and water utilities apply necessary conservation measures.

Education

- Survey results indicate that facilities rarely evaluated the success of their education program due to time, staff and financial constraints.
- 70 percent of the respondents predict educational campaigns to be one of the future conservation trends.
- One facility superintendent in Michigan wrote that the education of public officials such as the mayor, council members and board members in water conservation should be a priority in areas where the water supply is inadequate or unreliable.
- Water systems that have active programs involving technical assistance, water surveys, incentives and ordinances may benefit more from a general awareness or education campaign than a system that only implements an education program.

Financial Incentives

- Water conservation will increase among end users if price appropriately reflects the true value of water.
- Measuring water use by metering service connections is a prerequisite for other conservation measures such as pricing, education and leak detection.
    1. When coupled with public education campaigns and appropriate pricing structures, metering can sensitize end users to the importance of water conservation.
    2. Metered water provides revenue and useful information for water system audits for the utilities.
- The promotion of water efficient technology and services is cost-effective for both the water supply facility and the end user.
    1. End users can save on costs of water and energy when upgrading to new plumbing devices, appliances and lawn watering systems.
    2. Water supply facilities can delay, reduce or avoid expansion-related capital costs of needed water supply and wastewater facilities by reducing water demand.
- Leak detection and repair are some of the most practiced conservation activities by water systems surveyed in the Great Lakes region. Water system audits and leak detection and repair programs will improve the operations of water supply facilities by
    1. Reducing the water loss in the system
    2. Reducing water production costs
    3. Providing more water to sell to end users

Introduction

Water conservation can alleviate problems with inadequate water supplies and reduce the stresses on aquatic ecosystems because less water must be removed from natural water bodies. In particular, some locales can benefit from water conservation as they seek to address increasing water demand and attempt to preserve ecosystem integrity. As communities work to develop and implement water conservation programs, they need to have access to appropriate knowledge of what measures are best suited to their individual needs.

Water conservation is defined as the actions taken to reduce water use by improving the efficiency of various uses of water. As part of a community's overall management of water resources, water conservation is commonly associated with water demand management strategies, which serve to control or influence the amount of water used (Tate, 1990). Water resource management requires balancing the development of adequate water supplies with the needs of the utility's customers. Traditionally, water utilities have focused primarily on developing additional supplies to satisfy increasing demands associated with population growth and economic development. Increasingly, however, water utilities throughout the United States and Canada are recognizing that water conservation programs can reduce current and future water demands to the benefit of the customer, the utility and the environment.

The information in this briefing paper presents survey results of water conservation practices in the Great Lakes states and provinces. This survey gathered information provided by 136 water supply facilities in the region. The survey posed questions about water conservation activities, water conservation planning efforts, financial incentives to conserve water, governmental regulations that mandate conservation, future trends in water conservation, and planned or existing education programs. The survey results, which primarily focused on the municipal water sector, provide a starting point for future research and development of water conservation guidelines and regional policies. This paper provides background information from previous studies that explored various aspects of water conservation and additional research into water conservation regulations at the federal, state/provincial and local levels.

A portion of the background information in this briefing paper is from the Great Lakes Commission report, "Selected Guidelines of Water Conservation Measures Applicable to the Great Lakes-St. Lawrence Region." This report was developed to support the assessment of water use data and information under the Great Lakes Commission's report, "Toward a Water Resources Management Decision Support System for the Great Lakes-St. Lawrence River Basin." The Water Resources Management Decision Support System project, which began in August 2000, was funded by the Great Lakes Protection Fund.

This paper is one component of a larger project, titled "Developing a Water Conservation 'Toolkit' for the Great Lakes Region," which is also funded by the Great Lakes Protection Fund to support the implementation of the 2001 Great Lakes Charter Annex. Directive #3 of the Annex calls for a water resources decisionmaking standard that includes water conservation measures. The survey results will have immediate application to the Annex

process and will also help provide the information needed for the next steps of this project, which is to select and analyze cases studies of water facilities that employ unique and innovative water conservation practices.

Although regional conservation goals should be developed, individual states, provinces, municipalities and other water users also need to adopt those practices that are best suited to particular situations, including climate, existing infrastructure and social behaviors.

Background

The states and provinces of the binational Great Lakes-St. Lawrence River region are blessed with an abundance of high quality fresh surface water. Collectively, the Great Lakes and their connecting channels contain 6.5 quadrillion gallons (24.6 quadrillion liters) of surface water, equaling 20 percent of the world's supply and 95 percent of the U.S. supply. Due to this seemingly inexhaustible supply of fresh surface water, decisionmakers in the Great Lakes region have historically had minimal concern with water supply management issues such as water conservation. These concerns have heightened in recent decades, however, with increasing frequency of localized water management conflicts and the broader realization of the Great Lakes system as a large, yet finite supply of freshwater.

Localized Water Supply Management Conflicts

While the Great Lakes-St. Lawrence River region as a whole continues to have ample water supplies to meet the needs of its people, localized water supply shortages are becoming more frequent. Several cases in Michigan are illustrative of the need for innovative water resources management and conservation programs to ensure the adequacy of surface and ground water supplies to meet local requirements. For example, Monroe County, located in the southeast corner of the state, relies on groundwater for drinking water and irrigation, but aquifers have been depleting due to quarry operations (Behnan, 2002). Oakland and Macomb counties, also in the southeastern portion of the state, likewise have recently experienced aquifer depletion due to low rainfall, higher than normal temperatures and rapid residential development (Patterson and Garrent, 2002). In Saginaw County, similar climatic conditions, along with increases in groundwater-based agricultural and golf course irrigation, have resulted in a loss of residential water pressure for extended periods during the summer months (Saginaw County Dept. of Health, 2002).

Not only are in-basin demands on the water supply raising concerns for the long-term sustainability of the water resource, but communities that lie just outside the basin have begun to look toward Great Lakes surface water as a source to supplement their own supplies. In the past 15 years, communities such as Lowell, Indiana; Pleasant Prairie, Wisconsin; London, Ontario; and Akron, Ohio, have proposed or established diversions of Great Lakes water to meet expanding water supply needs.

Many experts believe that demand for Great Lakes water inside as well as outside the basin is likely to increase especially in areas of high urban growth such as the Akron area of Ohio, the Chicago-Gary region in northern Illinois and Indiana, the metropolitan area of Detroit, Mich. and the suburbs of Milwaukee, Wis. For Chicago and its suburban communities, the Northeast Illinois Planning Commission projects that the region's population will jump from 8 million to nearly 10 million by 2030, causing water shortages in such suburban cities as Naperville, Waukegan and Joliet. In Michigan, Detroit's Water Department, which serves 4.3 million people in 126 communities, predicts its service area will swell to 6.15 million people in 50 years. It hasn't projected how much that will boost the amount of water it pumps from Lake Huron and the Detroit River, now averaging 677 million gallons a day (Heinline, 2003).

Regional Conservation Initiatives

Uncertainties related to potential increases in water demand and the need for growth and expansion of public water supply systems have contributed to greater interest in water conservation, particularly a uniform approach to conservation at the regional level. In its February 2000 report to the governments of the United States and Canada, the International Joint Commission (IJC) observes, "Because of a possible downward trend in net Basin (water) supply in the 21st century, water conservation and demand-management practices should become increasingly important components of any overall sustainable use strategy." The report suggests, "Implementation of the Basin Water Resources Management Program – to which the states and provinces are committed under the Great Lakes Charter – could provide the opportunity to launch a water conservation initiative."

Through the Great Lakes Charter Annex, the region further committed itself to the pursuit of responsible water management through a new decisionmaking standard for new and increased water withdrawals. The Annex calls for a decisionmaking standard based on four principles. The first of these is "preventing or minimizing Basin water loss through return flow and implementation of environmentally sound and economically feasible water conservation measures."

A commitment to water conservation is clearly an essential consideration to any new water withdrawal proposal. Implementing water conservation measures within the basin also provides the region's decisionmakers with a basis to insist on such measures by prospective out-of-basin users. Dennis Schornack, chair of the U.S. section of the IJC, emphasizes the importance of the water conservation measure in his commentary to The Detroit News (July 10, 2003): "The cornerstone of Annex 2001, an amendment to the Great Lakes Charter of 1985, is the notion that water conservation at home is the best defense against diversions. Strong in-basin conservation policies are critical to the legal defense of the Great Lakes against the inevitable demands of our neighbors."

The purpose of this briefing paper is to provide a greater understanding of the current state of water conservation practices within the public water supply sector in the region and to inform, discuss and advance the development of water conservation measures under the Charter Annex implementation process.

Survey Methodology and Results

Content

The intent of this survey was to assess the current status of water conservation in the Great Lakes region and to select municipal water supply facilities that may serve as case study examples of innovative water conservation practices. The survey was not designed to assess the full extent that conservation practices are employed, in terms of resources allocated to their implementation, the frequency at which they are employed within the water system's service area, or the degree at which a conservation policy or plan is fully implemented. It does determine what types of conservation activities are practiced and which activities are practiced more widely than others.

Topics covered by the survey include water conservation activities, formal plans, financial incentives, guidelines, regulations, future trends in conservation activities and education. Refer to Appendix A for survey forms in English and French.

Additionally, a few sections of the survey gathered background water use information from respondents. This information included the water withdrawal source, service population, average daily water use, and residential and commercial demand. The background information is used to analyze conservation trends among facilities of a certain size or among facilities that depend on a certain source of water (i.e., groundwater or surface water).

Questions were developed and translated into French (for facilities within the province of Québec) by project staff and were reviewed by project members.

Design

The survey was designed to be quick and simple for water supply managers to answer. Most questions could be answered by checking items from a list. The respondents were also able and encouraged to check multiple answers to many of the questions. This technique standardized responses, making the form easy to fill out and the responses easy to interpret and analyze. To further increase the response rate, respondents were instructed to estimate or leave blank any questions that were not easily answerable and move to the next question.

Facility Selection and Distribution Methodology

Facilities were selected from databases provided by state and provincial water resource managers. The following parameters were used to select facilities for this survey:

- One third of the total selected facilities (175 facilities) were to be from Canada (Ontario and Quebec) and two thirds (350 facilities) from U.S. Facilities from six of the eight Great Lakes. Facility contact information was not available from Indiana and Wisconsin.

- Selection was based on three facility size categories determined by the project advisory committee. 75 surveys were sent to small facilities, defined as those that produced an average of 50,000 gallons per day (gpd) to 100,000 gpd. 300 surveys were sent to medium-sized facilities, defined as those that produced an average of 100,001 gpd to 1 million gallons per day (mgd). 150 surveys were sent to large facilities, defined as those that produced an average of greater than 1 mgd.
- At least 5 percent of the surveys sent within each category were directed to each state or province. If the number of facilities within a category was small, surveys were sent to all facilities in the category. This was the case for some of the states with jurisdiction covering a relatively small portion of the Great Lakes basin.

Table 1: Available Records (adjusted after removing duplicates)

	50k≥100k gpd	100k gpd-1 mgd	≥ 1 mgd	Total
Illinois	3	45	124	172
Michigan	141	373	178	692
Minnesota	2	12	5	19
New York	48	116	42	206
Ohio	40	85	58	183
Ontario	33	100	54	187
Pennsylvania	6	7	3	16
Québec*	0	288	65	353
Total	273	1,026	529	1,828

*Facility size estimates based on average per capita use and population estimates provided by the province.

Based on the initial number of facilities per jurisdiction, a matrix was developed to categorize the above information. Additionally, random number tables were generated in Excel for the selection process.

Québec was unique since it provided records by population. Average per capita water use was assumed to be 70 gpd. Because this figure is an estimated average of residential water use, this figure may not necessarily be correct. However, it seems to be within a reasonable range. Table 1 summarizes the number of records by jurisdiction after deleting duplicate records.

Table 2: Survey Sent by Jurisdiction and Facility Size

	50k≥100k gpd	100k gpd-1 mgd	≥ 1 mgd	Total
Illinois	3	16	31	50
Michigan	32	89	44	165
Minnesota	2	12	5	19
New York	12	30	12	54
Ohio	10	20	17	47
Ontario	11	31	15	57
Pennsylvania	5	7	3	15
Québec*	0	95	23	118
Total	75	300	150	525

*Facilities size estimates based on average per capita use and population estimates provided by the province.

Table 3: Surveys Sent – Percent of Total by Category

	50k≥100k gpd	100k gpd-1 mgd	≥ 1 mgd	Total
Illinois	4.00	5.33	20.67	9.52
Michigan	42.67	29.67	29.33	31.43
Minnesota	2.67	4.00	3.33	3.62
New York	16.00	10.00	8.00	10.29
Ohio	13.33	6.67	11.33	8.95
Ontario	14.67	10.33	10.00	10.86
Pennsylvania	6.67	2.33	2.00	2.86
Québec	0.00	31.67	15.33	22.48
Total	100.00	100.00	100.00	100.00

Table 4: Percent of Survey Sent Compared to Available Records

	50k≥100k gpd	100k gpd-1 mgd	≥ 1 mgd	Total
Illinois	100.00	35.56	25.00	29.07
Michigan	22.70	23.86	24.72	23.84
Minnesota	100.00	100.00	100.00	100.00
New York	25.00	25.86	28.57	26.21
Ohio	25.00	23.53	29.31	25.68
Ontario	33.33	31.00	27.78	30.48
Pennsylvania	83.33	100.00	100.00	93.75
Québec	0.00	32.99	35.38	33.43
Total	27.47	29.24	28.36	28.72

Tables 2 through 4 display the survey distribution by jurisdiction and by facility size category. A total of 525 surveys were sent to facility managers. About 31 percent of the surveys (165) were sent to facilities in Michigan; the largest number of surveys sent to an individual jurisdiction. Since more than 99 percent of the state of Michigan is within the Great Lakes basin, sending the largest number of surveys to Michigan seemed appropriate. In contrast, a smaller percentage of the surveys were sent to facilities in Minnesota (3.62%) and Pennsylvania (2.86%), corresponding to the smaller portion of the basin within their jurisdiction. Because the total number of in-basin facilities in these states was small, surveys were sent to nearly all the facilities.

Surveys were mailed to randomly selected water supply facilities on March 21, 2003. Facility managers were given 30 days to respond by mail, fax, or email. Surveys were also made available on the project website (http://www.glc.org/water/conservation). Follow up notices requesting the return of the surveys were sent at the end of April to those facilities that had not responded by the deadline date. The notice also extended the deadline to May 16, 2003. An additional notice was sent to facilities in Ontario by the Ministry of Natural Resources, in order to generate increased interest in the survey in that province. Respondents were given the option to send survey responses to either the Great Lakes Commission or the Ontario Ministry of Natural Resources. An additional five responses from Ontario resulted from the mailing.

Responses

Within the first two weeks, the majority of the completed surveys were received at the Commission office. The balance of the respondents provided their completed surveys via email and fax. By the new deadline of May 16, a total of 136 survey responses had been received. Response totals are summarized by jurisdiction and by facility size in Table 5 below.

Table 5: Survey Response

	50k≥100k gpd	100k gpd-1 mgd	≥ 1 mgd	Total
Illinois	0	6	9	15
Michigan	4	22	14	40
Minnesota	1	6	2	9
New York	2	5	3	10
Ohio	3	6	7	16
Ontario	2	10	6	18
Pennsylvania	1	1	2	4
Québec	0	20	4	24
Total	13	76	47	136

The overall response rate was approximately 26 percent (136 responses out of 525 mailed). Facilities in the state of Michigan had the highest number of responses (40 responses out of 165 surveys mailed), followed by those in the province of Québec (24 responses out of 118 surveys mailed). Response rates are summarized in Table 6. From a percentage standpoint, Minnesota had the highest response rate with 47.37 percent returned. New York was the lowest with an 18.52 percent response rate.

Table 6: Survey Response Rate in Percent

Jurisdiction	Response Rate
Minnesota	47.37%
Ohio	34.04%
Ontario	31.58%
Illinois	30.00%
Pennsylvania	26.67%
Michigan	24.24%
Québec	20.34%
New York	18.52%
Facility Size	
50K to 100K gpd	20.00%
100K gpd - 1 mgd	18.00%
> 1 mgd	28.67%
Overall Response Rate	25.90%

The survey has some limitations. Only 136 out of the 1828 available facilities [not including facilities from Wisconsin (234 facilities)[1] and Indiana (71 facilities)[2]] participated. Therefore, the survey represents 7.44 percent[3] of the facilities in the basin. It should be noted that the sample of facilities that responded to the survey is a stratified representation of the total number of facilities in the basin. Table 7 below presents the response sample representation of total facilities in the basin by facility size and jurisdictional location. For a more comprehensive survey of the

[1] Based on the Great Lakes Commission's regional water use database for 2000 data. It contains only principal facilities (those using over 100,000 gallons/day).
[2] Based on facilities with a withdrawal capacity of 100,000 gallons/day or more
[3] Based on available records from jurisdictional water use data collection programs

region, additional facilities in the region must be surveyed, including facilities from the states that did not participate. Follow-up telephone surveys will help verify written survey responses.

Table 7: Response Sample Representation of Total Facilities* in the Basin
*based on available records from jurisdictional governments

Jurisdiction	50k≥100k gpd	100k gpd<1 mgd	≥ 1 mgd	Total
Illinois	0.00%	13.33%	7.26%	8.72%
Michigan	2.84%	5.90%	7.87%	5.78%
Minnesota	50.00%	50.00%	40.00%	47.37%
New York	4.17%	4.31%	7.14%	4.85%
Ohio	7.50%	7.06%	12.07%	8.74%
Ontario	6.06%	10.00%	11.11%	9.63%
Pennsylvania	1.67%	14.29%	66.67%	25.00%
Quebec	0.00%	6.94%	6.15%	6.80%
Total	4.76%	7.41%	8.88%	7.44%

Summary of Results

In general, the survey results provided a sample of conservation activities across the region and among different community sizes. Most facilities that responded do implement one or more conservation activities, but no single conservation activity is done by all facilities. As discussed in the survey content section of this chapter, the survey only assesses what types of conservation activities are practiced, not the full extent to which they are implemented in the facility's service areas.

Table 8: Frequency of Water Conservation Activities

Activity	Frequency	Percent
Meter Calibration and Replacement	84	63.20%
Leak Detection	80	60.20%
Consumer Education	64	48.10%
Water Restrictions	59	44.44%
Water Audits	29	21.80%
Increase Percent of Metered Connections	27	20.30%
Industrial/Commercial/ Institutional Advice	12	9.00%
Other	11	8.30%
Install/Subsidize POU Low-Flow Fixtures	10	7.50%
Inverted Pricing Blocks[4]	4	2.90%

Table 8 summarizes the response frequency to each conservation activity. The majority of facilities participate in meter calibration and replacement activities (63.20%) and leak detection (60.20%). The two activities may be favored among facilities because they may provide a cost savings to their operations. Consumer education (48.10%) and water restrictions (44.44%) were the next activities most frequently implemented. Financial incentives such as inverted pricing

[4] Also known as increasing pricing bock, water rates increase as usage increase.

blocks (2.90%) and install/subsidize POU low-flow fixtures (7.50%) seem to be the least implemented practices among facilities.

Reasons as to why facilities undertake water conservation activities were assessed through the survey by posing the question, "What are objectives of the facility's water conservation program?" Many of the facilities had multiple objectives, which are reflected in the response frequencies summarized in Table 9. The most frequent response was lowering water loss in the system (69%), followed by lowering overall water use (52.70%).

Table 9: Conservation Program Objectives

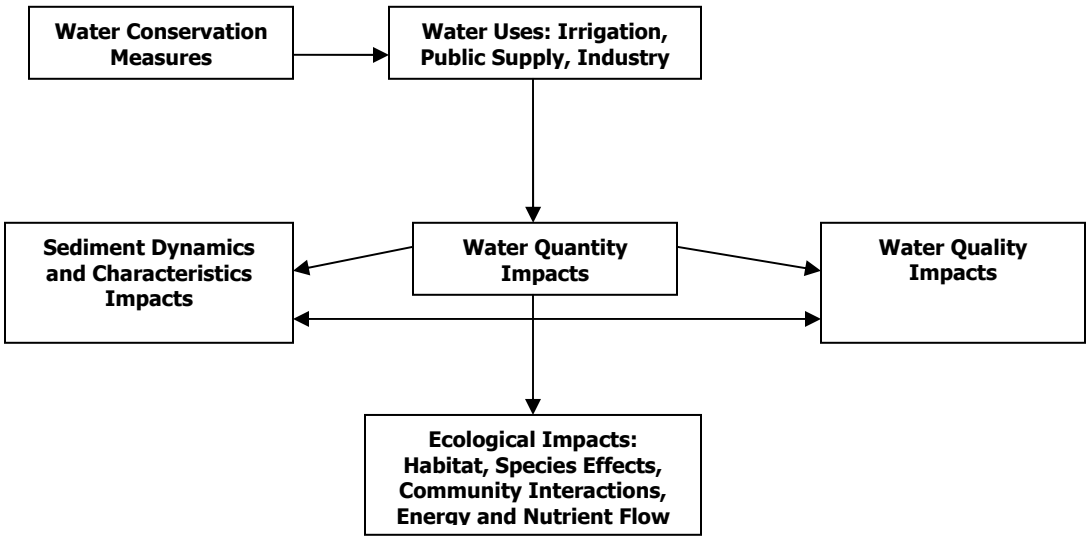
Activity	Frequency	Percent
Lowering Water Loss in the System	89	69.00%
Lowering Overall Water Use	68	52.70%
Control Production Costs	41	31.80%
Drought Contingency	38	29.50%
Other	7	5.4%

The next sections of the report will describe in greater detail various aspects of water conservation including planning and regulations, education and financial incentives. Each section will present an overview of the particular aspect of water conservation and summarize related survey responses from water supply facilities in the basin. Concluding observations on water conservation are listed at the end of each section.

Linkage between Water Conservation, Water Quality and Ecosystem Health Improvements

When water supplies are scarce, human water needs may stress the water resource and compete with the water needs of various ecological communities. The amount of water that can be withdrawn from freshwater systems before their function and productivity, native species richness, and ecological services become severely degraded is limited (The Nature Conservancy, 2003). Ecosystem health is intricately linked to quantity and quality of water in the system. Various insects and fish depend on adequate water levels at certain stages in their life cycle. Whole wetland complexes depend on stable water levels (Limno-Tech, Inc. and Slivitzky, 2002). Figure 1 is a schematic illustration of how conservation may mitigate water withdrawal and use impacts to the ecosystem.

Figure 1: Relationship between water conservation and ecosystem health



Evidence that the hydrologic regime is one of the key drivers of freshwater ecosystems exists (The Nature Conservancy, 2003) (Poff, 1997). Studies conducted in the Great Lakes-St. Lawrence River basin on various flora and fauna have demonstrated that various aquatic organisms depend on the water resources and hydrologic flow regime of a given ecosystem. Examples of these studies include the examination of vegetative responses in Michigan coastal wetlands to interannual fluctuations in Great Lakes levels; water withdrawal impacts on brown trout habitat losses in lower Michigan; and low water level impacts on northern pike in the Lake Champlain wetlands (Limno-Tech, Inc. and Slivitzky, 2002).

As part of the Michigan Natural Resources Inventory (MNFI) sampling program of Michigan's Great Lakes shorelines from 1987 to 1998, a 1997 MNFI study examined the vegetative responses in Michigan coastal wetlands and marshes to interannual fluctuations

in Great Lakes levels. The project's objectives were to examine the changes in species composition between sampling events, to relate the changes to differences in water level fluctuations, and to develop a Great Lakes marsh classification system based on the variation of vegetation. Data were collected when extreme high water levels occurred, and in 1994, when near average water levels occurred. Minc (1997) also found fluctuating lake levels not only effect a change in water depth in marshes, but also effect a broad range of associate stresses to which plants must respond. These stresses include changes in water current, wave action, turbidity (clarity or light penetration), nutrient content or availability, temperature and sediment displacement. Because individual species display different tolerance limits along one or more of these stresses, species composition can also change dramatically within a community. The study found water level regulation has significantly reduced the occurrence of extreme high and low water levels. Disruption of the natural wetland cycle due to water level regulation favors species intolerant of water depth change and excludes species that depend on these water level fluctuations for their life cycle.

Another study examined the impacts of irrigation withdrawals on a lower Michigan trout stream. This study was published in 1984 by the Institute of Water Research at Michigan State University. The study used the Instream Flow Incremental Methodology (IFIM) to accurately simulate the hydraulic characteristics of the stream and to predict brown trout (*Salmo trutta*) habitat locations within the stream. Brown trout habitat losses were most critical in the month of July, with reductions of up to 19 percent. A greater percentage of the remaining fish experienced negative growth rates as a result of reduced habitat availability. Benthic macroinvertebrate habitat was less impacted by irrigation withdrawals. This study also described a method for assessing the impacts of water withdrawal from the stream channel for crop irrigation (Kevern et al., 1984).

In 1997, the New York State Department of Environmental Conservation investigated the effect of water regulation on fisheries, as part of an IJC effort to examine control regulations of Lake Champlain. The study reported that healthy northern pike populations exist throughout Lake Champlain wetlands, but tend to be more dominant in the low-gradient wetlands located near the northern portions of the lake. Flooded terrestrial vegetation such as grasses, grass-bush-tree combinations, and emergent aquatic plants were preferred habitats for spawning. A water level elevation above 30 meters during the spawning period was required for access to, and flooding of, preferred habitats for egg deposition. The study concluded that lake-level regulation should allow inundation of this habitat for 40-50 days at least once every 3 years to ensure egg and fry survival. Dropping water levels during the critical egg and spawning period would have an adverse effect on northern pike production. Reduction of lake elevations from 31 to 29.5 meters would eliminate about 42 percent of the 37,500 mapped wetlands.

The extent that conservation can mitigate water quantity impacts to the ecosystem at the localized level has not been largely investigated in the Great Lakes region. Because the region is generally rich in water resources, published cases where municipal water needs have adversely impacted ecosystem health are few. As described above, most studies focus on hydrologic requirements for the survival of certain species or habitats. A small-scale

study in southeastern Mich. did attempt to quantify the environmental improvements of a water conservation program in an urban area.

A small rain barrel demonstration project in Dearborn, Mich., examined ecosystem responses to water conservation efforts in a Great Lakes tributary watershed. The Friends of the Rouge River and the city of Dearborn distributed 183 free 54-gallon rain barrels in 2000 and 2001 in this demonstration project. The goal was to evaluate how well rain barrels reduced the amount of rainwater and pollutants discharged in a storm surge into the Rouge. This project aimed to restore a more natural flow regime to the Rouge River during rainstorm events and to reduce the city's costs for future construction and maintenance of combined sewer overflow retention and treatment facilities. Rain barrels were installed in two adjacent neighborhoods in Dearborn where sewer flows were electronically monitored. Data collected before the project was compared with data collected during the two-year test period to determine if the water retention by rain barrels impacted sewer discharge rates into the Rouge River. The combined sewer overflow discharge monitoring found that the project had no significant effect on storm water discharge into the Rouge River. This finding was not surprising to project administrators because the project was small relative to the total volume of storm water. The project found that people liked rain barrels, the barrels captured most of the rain that falls on the roof, and rain barrels are a good tool to sensitize residents about storm water issues. The Friends of the Rouge River would like to expand the project to other neighborhoods to have measurable results.

Studies in the western United States demonstrate how conservation may help in the recovery of a stressed ecosystem. An extreme case of where municipal water demand outstripped the ecosystem's abilities to function involves the water management regime of Mono Lake, California. Over the past 40 years, the growing public supply demands of Los Angeles decreased the water levels of Mono Lake and degraded its ecosystem's functions. By California Supreme Court order, the City of Los Angeles was obligated to implement water replacement and conservation programs to restore Mono Lake, and the ecosystem is beginning to show signs of recovery. Refer to Appendix D for a more detailed summary of the Mono Lake story.

The Mono Lake example demonstrates how state policies and local initiatives can restore severely degraded ecosystem. Preventive conservation initiatives, if established early enough, may prevent ecosystem degradation. Water conservation principles being considered under the Great Lakes Charter Annex implementation process will provide an opportunity to establish a water conservation protocol for new and expanded water withdrawal and use projects. Currently, some federal, state/provincial and local conservation policies do exist in the Great Lakes region and are described in the following chapter.

Conservation Planning and Regulations

Federal Conservation Legislation and Policies – United States

At the federal level, the United States promotes the conservation of water through two laws, the Energy Policy Act of 1992 and the Safe Drinking Water Act (SDWA). The U.S. Energy Policy Act of 1992 (EPAct) mandates the replacement of old pumping devices to more water-efficient devices. It establishes maximum water use levels for toilets (1.6 gallons per flush), urinals (1.0 gallons per flush), showerheads (2.5 gallons per minute) and faucets (2.5 gallons per minute). The cumulative projected water savings resulting from this act will be 6 to 9 billion gallons per day by 2020 among residential and nonresidential customers (Vickers, 2001). A 2000 U. S. General Accounting Office (GAO) Report to Congress evaluated the impacts of federal plumbing standards on consumption levels and on investments in drinking water infrastructure. The GAO reported that by 2020, water consumption could be reduced by about 3 to 9 percent, and local utilities would save from $165.7 million to $231.2 million in planned infrastructure investments from the reduction in consumption.

Through the U.S. Environmental Protection Agency (U.S. EPA) and the SDWA, the federal government has initiated various conservation efforts in partnership with state and local governments. Section 1455 of the 1996 Amendments to the SDWA requires the U.S. EPA to publish in the Federal Register guidelines for the development of water conservation plans. These guidelines are designed to be used by public water systems of various sizes and take into consideration such factors as water availability and climate. The U.S. EPA issued the Federal Register guidelines on Aug. 6, 1998 (Ivanovich, 2001). At their discretion, states may require water systems to submit a water conservation plan consistent with the U.S. EPA or any other guidelines as a condition of receiving a loan under the Drinking Water State Revolving Fund (DWSRF). The SDWA established the DWSRF to support infrastructure improvements to drinking water systems. A summary of the U.S. EPA conservation guidelines is included in Appendix C.

The water conservation survey asked water supply managers if they use the U.S. EPA guidelines as well as other guidelines. In general, less than 40 percent of the respondents used guidelines, and only two respondents used U.S. EPA guidelines. While developing guidelines is a worthy cause, especially for water facilities in areas of the country where water resources are scarce, survey results show that few facilities in the Great Lakes region depend upon these guidelines to develop conservation programs.

The federally mandated Source Water Assessment Program (SWAP) may provide an opportunity for state and local agencies to assess water sources not only for quality, but also for quantity concerns. As part of the 1996 SDWA Amendments, SWAP provisions require states to: (1) delineate source water assessment area boundaries for all public water systems; (2) inventory existing and potential sources of contamination within these boundaries; (3) determine the susceptibility of the water systems to contaminants; and 4) make the assessments available to the public. SWAP is highly proactive in that its goal is to minimize threats to water supplies (Hodgson 2002). Under this program, threats to water

supplies could expand to include the forecasted increase in water demand. This program may help water supply managers understand the status of their water source and help discern the appropriate conservation measures necessary to ensure the long-term preservation of the resource.

Federal Conservation Legislation and Policies – Canada

While no Canadian federal legislation mandating water conservation exists, the federal department, Environment Canada, takes a national leadership role in promoting the wise management of Canada's freshwater resources through the 1970 Canada Water Act. The 1867 Constitution Act gives provinces ownership and day-to-day management responsibilities over their water resources. Environment Canada actively promotes a partnership approach among the various levels of government and private sector interests that contribute to and benefit from the wise management and sustainable use of the resource.

In 1987, the federal government released its Federal Water Policy, which gives focus to the water-related activities of all federal departments and provides a framework for action as water resource issues and concerns continue to evolve. The Federal Water Policy is a statement of the federal government's philosophy and goals for the nation's freshwater resources. Additionally, it proposes ways of achieving these goals through several strategies. The two principal goals of the Federal Water Policy are to promote "the wise and efficient management and use of water" and "to protect and enhance the quality of the water resource." Parts of the five strategies in the Federal Water Policy address the need for the wise and efficient management and use of water. The first strategy promotes the application of realistic water prices. The policy states:

"The federal government is committed to the concept of 'a fair value for water.' To implement this concept in federal policies, programs and initiatives, the federal government will:

- endorse the concept of realistic pricing as a direct means of controlling demand and generating revenues to cover costs;
- develop new water-efficient technologies and industrial processes that minimize costs, and encourage water conservation and improved water quality;
- undertake, support and promote joint federal-provincial examination of the costs and pricing of water for both consumptive and non-consumptive water uses; and
- encourage the application of pricing and other strategies, such as the beneficiary/pollutor pays concept, to encourage efficient water use."

The public is seen as a significant player in encouraging water conservation. The Federal Water Policy states: "In order to promote public awareness and participation in programs and initiatives to improve and protect Canada's water resources, the federal government will encourage public participation and initiate, develop and deliver a national water conservation awareness program." Various innovative products on water efficiency have been developed, promoted and distributed by Environment Canada including a speaker's kit, bill stuffers, a consumer's guide and a fact sheet.

The federal government plays an active role in the creation of water conservation guidelines for federal facilities and municipalities. Environment Canada currently chairs the Interdepartmental Advisory Group on Water Conservation at Federal Facilities (WCFF), which has 28 members representing 16 departments/agencies. The WCFF was originally formed in 1990 to help implement the water conservation requirements of the Green Plan and Code of Environmental Stewardship. This group has developed a *Water Conservation Plan for Federal Government Facilities* and a *Manual for Conducting Water Audits and Developing Water Efficiency Programs at Federal Facilities*.

The federal government contributed to the development of municipal water conservation guidelines through the Canadian Council of Ministers of the Environment (CCME). The CCME, consisting of environment ministers from federal, provincial and territorial governments, works to promote the cooperation and coordination of interjurisdictional issues such as water, waste management, air pollution and toxic chemicals. This federal/provincial/territorial group developed the *National Action Plan to Encourage Municipal Water Use Efficiency*. The goal of the plan is "to achieve more efficient use of water in Canadian municipalities in order to save money and energy, delay or reduce expansion of existing water and wastewater systems, and conserve water."

Every two or three years since the early 1980s, Environment Canada has conducted a water use and pricing survey. It is sent out to all municipalities with a population greater than 1,000 and, now, a sample of municipalities with populations less than 1,000. Questions on the survey relate to wastewater and water uses, treatment and pricing. Responses are compiled in the water use and pricing database. The information collected and reported in this database is general in nature and is primarily aimed at the production of aggregate and summary statistics. It is available at http://www.ec.gc.ca/water/en/manage/use/e_data.htm.

State and Provincial Water Conservation Planning and Regulations

State and provincial water conservation planning exists usually as components of drought contingency plans and conservation programs. A Great Lakes Commission report (2002) assesses water use and conservation programs at the state/provincial and local levels. This information is summarized in Table 10.

Half of the Great Lakes states and provinces have adopted some sort of conservation planning program or activities. These efforts range in scope from permit requirements to conservation education programs. Through water withdrawal permitting programs, Illinois, Minnesota, New York and Pennsylvania require permittees to adopt water conservation measures. For example, New York legislation requires all new water permit applicants to develop a water conservation program. The New York State Department of Environmental Conservation developed "*Water Conservation Manual for the Development of a Conservation Plan*" (1989) to help water supply systems comply with the permit requirement.

Table 10: State/Provincial Water Conservation Programs and Drought Contingency Plans (as of January 1998)

Jurisdiction	*Conservation Program*	*Local Conservation Efforts*	*Drought Contingency Plan*
Illinois	For Lake Michigan water, conservation required and outdoor rules apply during growing season. System owners and end users both required to conserve. Promotion through printed materials. Permittees cannot exceed unaccounted-for-flow of 8 percent.	Municipal permittees have adopted ordinances and building codes requiring conservation.	None, but individual plans encouraged for permitted users. Governor's Drought Task Force discusses drought conditions.
Indiana	None, except during drought.	Local governments support conservation efforts during drought.	Three water shortage phases used with recommendations for action. First phases use voluntary reductions and public outreach. Phase III uses mandatory restrictions. Water Shortage Task Force can be formed to advise the governor.
Michigan	None	Individual municipalities and local governments use drought measures as necessary.	None, but ad hoc interdepartmental task forces have been formed.
Minnesota	Permits require all users to be efficient. Public water suppliers and agricultural irrigators must have conservation plans.	Local demand management measures are required to obtain approvals for new municipal wells or increases in authorized water volumes.	Current plan specific to Mississippi River, but being updated to whole state. Public suppliers and surface water users must have contingency plans. Drought plan includes mandatory restrictions. Multi-agency/stakeholder task force implements the plan.
New York	All new applications for public water supply permits required to have conservation programs. Goal to maintain unaccounted-for water below 15 percent. Publicity and consumer education efforts required.	Local entities may provide additional support.	State Drought Management Task Force recommends four different drought stages. Incremental restrictions are implemented by individual water systems as conditions worsen.
Ohio	None, except during drought.	Local entities may provide additional support	Four phases of drought are used. The second two phases use voluntary conservation and public education; phase four uses mandatory restrictions after governor declaration. Drought Executive Committee is activated in phase three.
Ontario	Building code and planning laws require low-flow plumbing and other conservation measures. Education initiatives promote conservation. Provincial Water Use Strategy guides efforts.	Municipal levels have regulations and are involved in education during low water conditions. Communities receive federal money to reduce public use.	Three drought indicator levels used. Level 1 is voluntary, Level 2 is regulatory and Level 3 is mandatory. Ontario Low Water Response Plan guides partnerships between local and provincial agencies. Local Water Response Teams develop conservation plans.
Pennsylvania	Public water suppliers using surface water required to have conservation program. Various conservation efforts are used.	Local entities may provide additional support.	Three drought stages used. The first two stages have voluntary restrictions of various levels. The third stage may also include mandatory restrictions. Water suppliers and commercial and industrial users required to have drought plans.
Québec	None, but provincial ministries provide financial support to local efforts and NGOs. The organization RÉSEAU-Environment promotes conservation through a variety of methods.	A range of conservation occurs at local scale, including infrastructure replacement, restrictions on water use, and education programs.	None
Wisconsin	None, but conservation plans recommended as part of wellhead protection plans (required for municipal wells). System losses regulated by Public Service Commission. Plumbing flows regulated by Department of Commerce.	Local entities may provide additional support.	Declaration determines the presence of drought emergency. Formal plan, stages not used. Mandatory restrictions imposed with declaration of drought emergency.

The authority to mandate water conservation at the state and provincial level appears to be an effective driving force for local governments and utilities to develop water conservation programs and plans. A 1998 American Water Works Association (AWWA) sponsored survey of state water conservation programs illustrates this point. Results found that 14 of the 15 states classified as conservation leaders by the survey have the authority to allocate or approve either surface or ground water withdrawals.

Aside from water conservation requirements attached to water permits, Ontario building and plumbing codes mandate low-flow fixtures for new construction. New construction are required to install 6 litre toilets, 3.8 litre urinals, 8.35 litres/minute faucets and 9.5 litres/minute showerheads. Replacement fixtures in buildings constructed before Jan. 1, 1996, must meet the following requirements: 13.25 litre toilets and 5.68 litre urinals.

Seven of the 10 jurisdictions implement formal drought contingency plans that include various levels on water restrictions depending on the conditions of drought. These plans appear to provide an appropriate structure for addressing emerging water shortage situations and are generally adaptable to changing water supply needs over the course of the year. Although conservation practices are mandated or encouraged at the state level, most of these practices are implemented at the municipal/local level.

Other pieces of state/provincial legislation may provide an effective mechanism to implement water conservation measures. For example, the Michigan Safe Drinking Water Act contains a provision that gives the state the authority to limit the water use of a municipal water system that is not compliant to the state drinking water standards. This provision [section 325.1015(4)] states:

> "The department may take appropriate action to limit water system expansion or limit water use from a public water supply until such time as satisfactory improvements are made in the system or operation to provide for a continuous, adequate supply of water meeting the state drinking water standards."

Other than the failure to meet state water quality standards, this provision has been used to limit water use in the Detroit water system due to water pressure concerns. In regards to the implementation of Directive 3 of Great Lakes Charter Annex, the state may broaden the application of its authority to limit water use as it relates to water quantity concerns since water quality and quantity issues are related. If the water supply is low, concentrations of regulated water pollutants will increase to the extent of falling short of state standards. The state may also attempt to pass legislation that further specifies this authority and provide model conservation ordinances from which municipal water systems may develop their own ordinances. Similar opportunities may lie in other Great Lakes states' drinking water legislation.

Conservation Planning at the Local Level

The survey posed several questions about the use of formal conservation plans and the factors that influenced the development of those plans throughout the region. More than half (65.4%) of the facilities who responded do not operate under any formal conservation plan. About 24 percent do have formal conservation plans, and about 10 percent were unsure.

Table 11: Formal Conservation Plans

Valid Responses	Frequency	Percent
No	89	65.40%
Yes	33	24.30%
Unsure	13	9.60%
Total	135	99.31%
Missing Reponses	1	0.70%
Total	136	100.00%

When asked about why a conservation plan has not yet been developed, the majority (66.30%) perceive that the water supply in their service area is adequate. The particular water source, whether Great Lakes surface water, other surface water or groundwater was not a determinant factor, in general, to the perception of abundant supply (Refer to Appendix B for water sources used by the survey participants).

There may also be some financial disincentives for water suppliers to develop and implement aggressive water conservation plans. As a business, municipal water supply systems have an interest in fully utilizing their systems to generate revenue to pay for capital improvements, system maintenance and operating cost. At the same time, however, water suppliers do discourage waste, especially from leaks in the distribution system, unmetered connections and from usage that may cause property damage. All communities should reassess the economic benefits of water conservation and revisit their belief that conservation reduces water-related revenue.

Other responses as to why conservation plans are not being developed and used include a lack of public concern (29.40%), financial disincentives [i.e., a loss in revenue] (see discussion above) (11.60%), political obstacles (10.30%) and other (16.30%). Additional reasons for why a formal conservation plan has not been developed are the following: public awareness of conservation only started in 2002, lack of information, lack of interest from local public officials, lack of time, conservation is not a priority, per capita consumption is low (71 gpd), and staffing constraints.

A major driving force in the development of conservation plans is the mandate established by regulatory requirements. About 58 percent of facilities operating under a plan were required to do so by regulation. Table 12 presents other factors leading to the development of conservation plans. Jurisdictions, in which the majority of respondents do have conservation plans, require conservation efforts – although not specifically a formal plan – as a condition to a water permit. The survey responses do not necessarily reflect the extent to which water permitting requirements mandate water conservation efforts, which may vary among jurisdictions. While New York has a program that includes this requirement, it applies only to new water permit applications. In contrast, Minnesota's water permit program requires all public supply systems serving more than 1,000 people to develop a conservation plan.

The New York Department of Environmental Conservation's Public Water Supply Permit Program (PWSPP) requires new water supply permit applicants to have water conservation programs as of 1989. However, only 10 percent of the New York facilities who participated in the survey claim to operate under a formal plan. Of the 10 New York facilities that responded to the survey, only four facilities needed to submit new applications since 1989. This fact partly explains the low response percentage. These four facilities did, in fact, submit conservation plans to New York's PWSPP. The reason why only one of the four facilities indicated that they had a plan remains unclear.

Table 12: Factors to Plan Development

Factors	Frequency	Percent
Regulatory Requirement	19	57.58%
Drought	13	39.39%
System Capacity Limits	13	39.39%
Projected Water Demand Increase	11	33.33%
Groundwater Supply	9	27.27%
Control Production	6	18.18%
Public Interest	5	15.15%
Other	3	9.09%
Poor Water Quality	0	0.00%

Five of the nine water systems in Minnesota that responded to the survey confirm operating under a formal conservation plan. Minnesota requires that all public water supply systems serving more than 1,000 people submit for approval an emergency and conservation plan. The plan must address supply and demand reduction measures, allocation priorities and must identify alternative sources of water for use in an emergency. An update to the plan must be submitted for approval every 10 years. These suppliers must employ water use demand reduction measures before requesting approval to construct additional wells or request an increase in authorized volume. All public water supply and water use permits have the following general water conservation stipulation: "The permittee shall, whatever practical and feasible, employ water conservation methods and practices that promote sound water management, including but not limited to the reuse and recycling of water, water saving devices, water scheduling, and public education." Of the four systems in Minnesota responding "No" or "Unsure" to operating under a formal plan, two of those systems are required by the state to develop plans.

Illinois' Lake Michigan water allocation program's most effective water conservation requirement is that unaccounted-for-flow must be 8 percent or less of a permittee's net annual pumpage. Illinois also requires the adoption of ordinances requiring water efficient plumbing fixtures, installation of closed system air conditioners in new construction or remodeling, installation of water recycling systems in new car washes and outdoor water use restrictions during the summer months. They also limit hydrant uses (e.g., street cleaning, fire fighting, water main flushing) to 1 percent or less of a permittee's net annual pumpage. Before an applicant receives a Lake Michigan water allocation they need to provide copies of the passed conservation ordinances. Permittees are required to submit a yearly water audit form which shows their unaccounted-for-flow.

Pennsylvania has been requiring the development of water conservation programs in surface water allocation permits issued to public water suppliers withdrawing surface waters of the Commonwealth since 1979. The water conservation program is to include

items where water-savings can be achieved as a part of effective management of the water system. Permittees are required to have customer metering in place or submit a plan to meter all unmetered customer connections usually within three years. The permittee is also required to have a metering testing and replacement plan in effect. Other items are leakage and loss control, water conservation education programs and the requirement for the installation of water saving plumbing fixture. The water supplier is also to implement the water conservation requirements of the Susquehanna or Delaware River Basin commissions if subject to their jurisdiction. The water supplier documents its implementation of water conservation measures through an annual permit compliance report.

Ontario is currently reviewing its permitting process to include water conservation measures.

Table 13 displays the response frequency for facilities operating under a formal conservation plan by jurisdiction. The table rows that are in bold are jurisdictions (Pennsylvania, Illinois, Minnesota, and New York) that require conservation efforts, although not always a formal plan, as part of their water permitting program. Other factors influencing the development of conservation plans that are worth noting are drought conditions (about 39%), system capacity limits (about 39%), projected water demand increase (about 33%) and groundwater supply (about 27%).

Table 13: Plans by Jurisdiction

Jurisdiction	Frequency	Percent
Pennsylvania	**3**	**75.00%**
Illinois	**9**	**60.00%**
Minnesota	**5**	**55.56%**
Quebec	6	25.00%
Ontario	3	16.67%
Ohio	2	12.50%
Michigan	4	10.00%
New York	**1**	**10.00%**
Québec	6	25.00%
Total	33	24.26%

Regulation at the Municipal/Local Level

As discussed in a previous section, regulations mandating water conservation occur at the municipal level. About 29 percent of respondents confirm that conservation is mandated by municipal regulation in their service area. Nonetheless, more than half of the respondents (61.40%) believe that no regulation mandating water conservation exists. Table 14 summarizes response frequencies for each type of regulation mandate for water conservation.

Table 14: Water Conservation Regulation

Mandate Type	Frequency	Percent
None	81	61.40%
Municipality	38	28.80%
County	4	3.00%
Unsure	4	3.00%
Municipality, County, and Township	2	1.50%
Township	1	0.80%
State/Province	1	0.80%
Municipality and Region	1	0.80%

One apparent trend among the response to water conservation regulations should be noted; the response to state and provincial regulations were considerably low, yet some

states and provinces do contain conservation measures through the regulation of their permitting program.

At the end of the survey, respondents were asked to comment about water conservation. Views on water conservation program mandates were diverse. One respondent located near Lake Michigan mentioned the need to implement conservation programs to inform residents. Currently, water restrictions are imposed in the respondent's service area based on capacity issues at the water treatment plant. Some water supply managers do not believe that legislative programs will help increase water efficiency beyond mandates for metering, water audits and other administrative practices that are part of sound utility financial management.

Concluding Observations

- The federal policies and initiatives administered through the U.S. EPA and Environment Canada may provide opportunities to apply conservation programs in the Great Lakes region.
- Nearly half of the Great Lakes jurisdictions do promote water conservation through various programs; the most effective programs appear to be those that marry conservation requirements to permitting.
- In general, conservation efforts among local jurisdictions are few; the lack of conservation efforts can be primarily attributed to the perception of adequate or abundant water supplies from all sources of water.
- An accurate assessment of water supplies along with a commitment to conducting forecasts of future water demand may help local municipalities and water utilities apply necessary conservation measures.

Education

Public education is generally thought to be a long-term solution to many environmental problems. As an important element to water supply management, educating the public on how to conserve water in the home will help reduce per capita water usage. Assuming that the service area remains the same, this will also reduce overall residential water demand. Education programs may include promoting the use of water efficient devices, academic curriculum for elementary and high school students, and consumer education.

Education about the value of water conservation is becoming increasingly important, particularly in areas where water is scarce. Many communities with unreliable water supplies, supplies under stress or located in arid climates, often have active public educational campaigns to conserve water. In reducing demand, community water systems hope to prolong the use of their current system infrastructure, delaying the big capital investment needed to obtain other water sources. For example, an education outreach program in Cary, N. C., aims to reduce per capita water consumption by 20 percent by the year 2020. The program targets adults and elementary students as well as customers through direct mail. Over the past two years, the town's population increased by 5 percent, but the volume of water sold has remained the same (AWWA, 2003).

Outdoor water usage also appears to be an area where water use could be significantly reduced. A recent study in Las Vegas, Nev., found homeowners over-water their lawns by about 40 percent on average. Communities, particularly in western United States, could save 30 percent of their water if people water their lawns appropriately (Sonner, 2003). The development of an education outreach program in Las Vegas may be a means to disseminate information on best lawn watering practices to the public. Educational programs on outdoor usage have been underway in other western regions of the United States. In Santa Rosa, Califor., the city has developed an outreach program for residents and commercial owners of large landscape sites to reduce landscape water use. The intent of the program is to reduce usage by 5 percent which translates to about 255.8 million gallons per year or $621,594 worth of water savings. This program works with residents to develop an efficient watering schedule based on high-resolution satellite imagery (Public Works, 2003).

Education programs and curricula have been developed for students of many learning levels from elementary school to college. An education program in the city of Tampa, Fla., is an innovative example. In order to meet the future water supply needs while being restricted to the Hillsborough River Reservoir as the primary water source, the city's water department initiated various projects and programs to ensure an adequate water supply for ever-increasing water demands; one of which is an education program on water conservation. This education program served a dual purpose; it aimed to increase students' scientific literacy in water resource issues as well as educate the community about important environmental issues. The students researched water resource issues and, with the assistance of a local television producer, developed public service announcements to promote Water Conservation Month (April). Video tapes of the public service announcements were distributed to the education channel for airing and to the Hillsborough County video office for the public to borrow and view at home. Students

also learned about the Hillsborough River and its importance as the city of Tampa's primary drinking water source by participating in a field trip to the Hillsborough River Water Treatment Plant. Its operation shows students the details of the surface water treatment. The program received an award for excellence from the Florida section of the AWWA in 1999 (Stokes 2002). Additional examples of education programs are available on the AWWA's Water Wiser web site, http://www.awwa.org/waterwiser/education/casestudies.cfm. Table 15 lists other online resources for water conservation education.

Table 15. Selected Online Education Resources

Project WET
http://www.projectwet.org/
Educating Young People about Water, University of Wisconsin
http://www.uwex.edu/erc/eypaw/
Water Wiser, American Water Works Association
http://www.awwa.org/waterwiser/CorePage.cfm?CI=9
Water Conservation and Water Science Reading List, City of Phoenix, Arizona
http://www.ci.phoenix.az.us/WATER/books.html
Water Efficiency/Conservation, Environment Canada
http://www.ec.gc.ca/water/en/links.cfm?category_id=3&sub_section_id=20
Water Efficiency Educational Materials, U.S. Department of Energy
http://www.sustainable.doe.gov/efficiency/water/weedtoc.shtml

While education programs attempt to change residential water use habits, they also provide a venue to promote the use of more water-efficient equipment (plumbing products, appliances, landscape irrigation equipment). Cities might consider running their education campaigns in conjunction with their incentive programs, such as a rebate program. Water systems that have active programs involving technical assistance, water surveys, incentives and ordinances may benefit more from a general awareness or education campaign than a system that only implements an education program (Flowers, 2003).

Educational Activities in Great Lakes Region and Survey Results

A little less than half of the survey respondents indicated that they use education programs as an element of their conservation program. The majority (63.50%) of these programs consist of water bill inserts or stuffers, which apparently are considered to be the most cost-effective method in distributing educational materials.

Table 16: Education Programs Frequency

Education Programs	Frequency	Percent
Water Bill Inserts/Stuffers	33	63.50%
Newspaper Pubs.	20	38.50%
School Programs	14	26.90%
Internet	12	23.10%
Special Events	11	21.20%
Special Mailings	10	19.20%
TV/Radio Commercials	9	17.30%
Other	7	13.50%

Other activities that were considered part of an educational program are listed below:

- Restrictive permit system

- Water conservation section to the annual Consumer Confidence reports[5]
- Booklets to water customers distributed upon request
- Student plant tours
- Leak detection kits
- Public displays at a commercial mall
- Rain barrel distribution
- Wellhead protection program
- Quarterly newsletter articles
- Customer handbook
- Leak detection inspections

Among those that indicated the use of education programs, response rates to the more detailed questions about these programs (e.g., program budget, funding sources and program evaluation) were low. A few observations about these responses can be made. Budget figures varied from $200 to $25,000 (US). Programs were mostly funded by water rate revenue. Other financial sources included grants and user fees. Survey results also indicated that facilities rarely evaluated the success of their education program due to time, staff and financial constraints.

Special Events

Special events may include such things as groundwater festivals, Earth Day activities, Drinking Water Week and groundwater simulations such as the one shown at the National Baby Food Festival in Fremont, Mich., home of the Gerber Products Company. The Waterloo-Wellington region in Ontario holds an annual Children's Groundwater Festival. Concerned citizens and festival volunteers in the area created this event to raise awareness about groundwater conservation among school children. Driven by 4,200 volunteers from municipal groups, education and industry organizations, and conservation authorities, the festival has reached 36,000 students from 40 schools. These festivals have now expanded across the province. In 2003, nine festivals took place in southern Ontario, and many more are expected to be added in upcoming years.

National Drinking Water Week is another special event that provides a forum for water utilities to educate the public on water conservation. Utilities across the United States and Canada, including those in the Great Lakes basin, participate in this weeklong public education campaign to raise awareness of drinking water and conserving water resources (AWWA, 2003).

Even though facilities in Wisconsin were not included in this survey, Green Bay, Wis., has held some noteworthy educational events. In 2000, the DePere High School Ecology Club wrote and produced "Acting for the Environment," a theatrical production about water usage that was presented to seven middle schools. In 2001, the DePere High School Ecology Club hosted Eco Jam, an event with music and display booths that focused on various aspects of water. A Groundwater Model Training workshop was held in 2002 to

[5] The U. S. EPA requires municipal water supply facilities to annually develop and distribute consumer confidence reports to their customers. Consumer confidence reports are mandated by the right-to-know provisions in the 1996 Amendments to the Safe Drinking Water Act.

educate teachers about the various aspects of groundwater and the use of the sand tank model (Kaster, 2003).

Educational Curriculum in the Great Lakes Region

About 27 percent of the respondents who have education programs indicated that school programs were a component to their conservation activities. These school programs could take the form of special events as described in the section above or education curriculum as part of physical science units. Two nationwide programs, Water Riches and Project WET, have been applied to classrooms in the Great Lakes states.

The Indiana Water Riches curriculum was adapted for Indiana from the Nebraska Water Riches curriculum by faculty at Purdue University in 1990 and 1991. Other state 4-H offices (youth arm of the USDA Extension Service of the Land Grant universities) have adapted the information specifically for their state. The curriculum is designed to encourage the conservation and protection of water resources among upper-elementary children. It consists of five units covering issues of water use, the water cycle, surface and groundwater, water pollution and water conservation. More information on the Indiana Water Riches program is available through the following website: http://www.four-h.purdue.edu/staff.home/natalie/waterriches.html.

Project WET is another education program used in the Great Lakes states. It is a multi-state and international initiative with programs in the United States and Canada. It provides education resources to teachers and students ages 5 to 18. Through the dissemination of classroom teaching aids and curricula, the program facilitates and promotes awareness, appreciation, knowledge and stewardship of water resources. The program's curriculum has been developed and field-tested by over 600 educators and resource managers working with 34,000 students nationwide. The program has contacts or coordinators for each of the Great Lakes states and provinces. More program information is available on the Project WET web site, http://www.projectwet.org.

Concluding Observations

- Education programs exist within less than half of the facilities in the Great Lakes region, consisting mainly of bill inserts.
- Survey results indicate that facilities rarely evaluated the success of their education program due to time, staff and financial constraints.
- 70 percent of the respondents predict educational campaigns to be one of the future conservation trends.
- One facility superintendent in Michigan wrote that the education of public officials such as the mayor, council members and board members in water conservation should be a priority in areas where the water supply is inadequate or unreliable.
- Water systems that have active programs involving technical assistance, water surveys, incentives and ordinances may benefit more from a general awareness or education campaign than a system that only implements an education program.

Financial Incentives

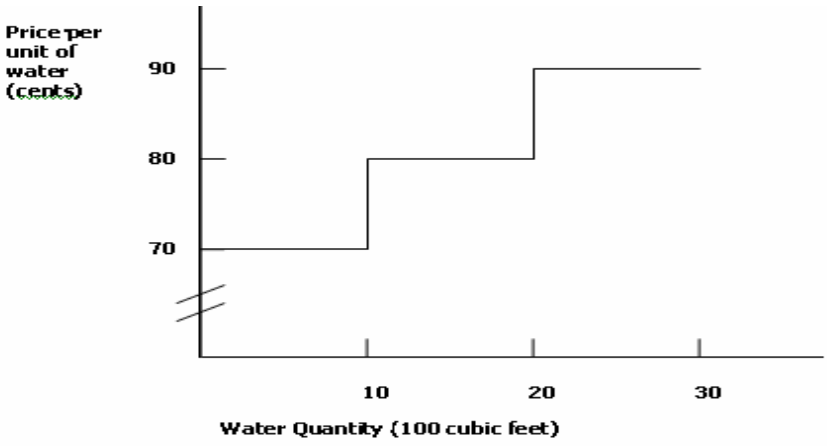
The pocketbook is one of the most immediate methods to influence consumers to conserve water. Water use should be accurately measured and priced appropriately, forcing users to realize and to consider all the costs of supplying water. Subsidizing water efficient technology such as low-flow toilets, showerheads and advanced irrigation timing devices will make them more market competitive to the traditional alternatives. In addition, water utilities may offer cost-saving services such as leak detection and water audits.

The Price of Water: The Economics of Conservation

The prices charged by water distributors do not promote efficiency of use. Because water is considered an essential commodity, the price level is artificially low, and the rate structure does not adequately reflect the costs of providing service to different types of customers. Efficient pricing requires the use of marginal, not average, costs. In order to adequately balance conservation with use, the customer should be paying the marginal cost of supplying the last unit of water. Marginal cost is defined as the change in the total cost of production resulting from an extremely small change (such as one more drop of water) in the level of output. As an indicator of resource scarcity, a rising marginal cost should, therefore, account for the amount of effort needed to procure each unit of the resource. Typically, regulated utilities are allowed to charge prices just high enough to cover the costs of running the operation; the water itself is treated as a free commodity. Both average cost pricing and ignoring the marginal user cost promote an excessive demand for water. Simple conservation actions, such as fixing a leaky faucet, are easy to overlook when water is cheap. In a large, populated city like Chicago, leaky faucets may account for a significant amount of wasted water (Tietenberg, 2000). Econometric studies indicate that water prices influence water conservation behavior; a 10 percent increase in price would be expected to result, on average, in a 2 to 5 percent reduction in demand, when all other factors that effect demand are held constant (Dziegielewski, 2003).

In order to rectify the inefficiencies of water pricing, the scarcity value for water should be included in the price. This may be accomplished by changing the traditional, uniform rate structure to an increasing block rate. This rate system raises the price per unit of water consumed as the amount consumed rises. As the price increases with the amount of water consumed, water conservation becomes more valuable. Figure 2 depicts the increasing block rate.

Figure 2: Increasing Block Rate Structure



Water rates may be classified under five different types of structures: flat rate, uniform rate, declining block rate, increasing block rate and seasonal rate.

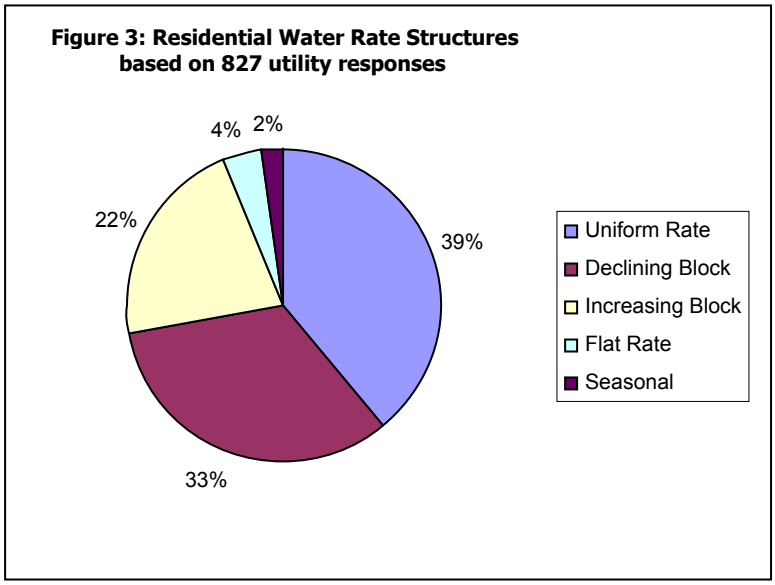
- *Flat rate* charges the user a fixed price regardless of the amount of water used.
- *Uniform rate* charges the user the same unit rate for all water usage.
- *Declining block rate* charges the user less as usage increases. The initial usage is charged at the highest rate and the rate decreases for usage that exceeds certain established rate block consumption ranges.
- *Increasing block rate* (inverted block rate) charges the user more as usage increases. The initial usage is charged at the lowest rate, and the rate increases for usage that exceeds certain established rate block consumption ranges.
- *Seasonal rates* fall into two categories: differentiated seasonal rates and summer seasonal rates or surcharges.

  Differentiated seasonal rate charges the user a higher rate for all water used during the summer season than for water used during the winter. The theory is that water used in the summer peak season costs more to provide because capital improvements are needed to keep up with a higher peak demand.

  Summer seasonal rate or surcharge is a premium rate charged only to users whose use in the peak season exceeds their average use during the winter or off-peak season.

According to a 1996 AWWA survey of 827 U.S. water utilities, almost 40 percent of the respondents used a uniform rate structure. Figure 3 shows the survey results.

Figure 3: Residential Water Rate Structures based on 827 utility responses



Source: WATER;\STATS 1996 Survey data: 1998 American Water Works Association

A 1997 discussion paper on water rate structures for the Regional Municipality of Waterloo Water Efficiency Master Plan highlights some advantages and disadvantages of uniform rate, declining block rate, increasing block rate and seasonal rates. Table 17 lists these advantages and disadvantages.

Table 17: Rate Structures		
Rate Structures	Advantages	Disadvantages
Uniform Rate	• Easy to understand • Stable and predictable revenue • Straightforward in application	• Not the most effective in encouraging water usage reduction
Declining Block Rate	• The preferred option for large water users	• Provides a decreasing incentive to efficient water use
Increasing Block Rate	• Encourages efficiency for users below minimum allowance or for uniform monthly users, by acting as a reward for efficient water use	• Residential customers may be subsidized by the higher rates paid by large-volume non residential customers that do not have significant peaking characteristics • May impose a financial penalty on large water users who have very little discretionary use
Seasonal Rates (Differentiated)	• Encourages users to be water use efficient during the peak season by reducing discretionary uses such as lawn watering • Leverage to encourage non-residential users to install water efficient technologies and institute efficiency programs	• Users with fairly steady year-round use which does not contribute to the summer peak are still required to pay a higher price to help pay for summer peaking facilities and costs. • Does nothing to encourage non-peak efficiency efforts.
Seasonal Rates (Summer)	• Equitable because it targets users who are responsible for the summer peak • Most effective of the water use efficiency rate formats in terms of reducing usage without increasing revenue instability • Eliminates rate penalty due to household size and number of dwelling units in a multi-residential structure • Can be tailored for each individual user rather than user class	• Complex to administer, due to the need to track average use for each customer • May encourage greater winter consumption in order to achieve a higher quantity limit during the peak season.

From the survey of water facilities in the Great Lakes region, only four out of the 136 facilities who responded use pricing structures to encourage water conservation. The most stringent pricing structure surveyed is from a township water department in western Mich.; by ordinance, water rates triple for excessive use from April through October. In Mackinaw City, Michigan, a flat rate is used rather than declining pricing structure. In Canada, one Ontario facility plans to increase water prices, and a Québec facility fixes water prices by user category. The pricing structure that the majority of facilities in the region use is unknown.

In summary, consumers respond to price. Generally, a higher water bill leads to lower water consumption over time. Rate structures that charge for the amount of water used and charge a higher rate for consumption above a certain level encourage customers to use water efficiently. Many water users consider water to be essentially "free" and are resistant to paying higher prices. Only when they understand that rates pay for all the costs of water service – including finding and building new water sources – are they willing to consider higher rates and water conservation measures.

Conservation-oriented water rate structures by themselves do not constitute an effective water conservation program. Rate structures work best as a conservation tool when coupled with a sustained customer education program. Customer education is important to establish and maintain the link between customer behaviors and their water bill. Utility

customers require practical information about water-conserving practices and technologies. Participation in other water conservation programs, such as plumbing-fixture retrofit and replacement programs, can also be enhanced by rate incentives and customer education. Finally, public acceptance of rate structure changes is often enhanced if customers understand the need for and benefits of water conservation (Municipal Research and Services Center of Washington, 1995).

Accounting for Water Use: Metering and Submetering

New York's 1989 Water Conservation Manual, describes metering as a "prerequisite for other conservation methods, such as pricing, education and leak detection." For public water suppliers, metering and submetering allow for the establishment of appropriate rate structures and give customers the ability to track water use. By using rate structures and metering, a customer who pays attention to water use can make a conscious effort to conserve water and receive financial benefits through reduced costs. When coupled with public education campaigns and appropriate pricing structures, metering can sensitize end users to the importance of water conservation.

Similarly, industrial facilities can install their own meters to monitor water use at various points in a production process so that potential conservation savings can be identified. A 1996 nationwide survey in Canada, covering 24.6 million people in 1,358 municipalities showed that metered communities use 34 percent less water than nonmetered communities (Sharratt, 2001).

Metering service connections as well as the calibration and replacement of meters are conservation activities that Great Lakes water facilities practice the most. 84 (60.20%) facilities surveyed calibrate and replace meters on a regular basis. 72 (about 53%) facilities surveyed in the Great Lakes region have 100 percent of their service connections metered. Chicago, one of the largest cities that still does not meter all of its residential and commercial water usage, is now leading an initiative to install meters to 350,000 non-metered customers (Speilman, 2003).

Water-Efficient Technology and Services – End Users

The use of water-efficient technology and services has financial benefits for both water supply facilities and the end user. Financial benefits from water-efficient plumbing fixtures, appliances and outdoor irrigation systems include:

- Water savings
- Reduced costs for energy and chemicals
- Reduced costs for water, sewer, electric and gas utility services
- Reduced costs for laundry and dishwashing detergents
- Reduced size and extended septic system life

Studies on the cost-saving of water-efficient plumbing fixtures alone illustrate substantial financial benefits to utilities. Studies of 16 U.S. localities show that the plumbing fixtures

standards mandated by the 1992 U.S. Energy Policy Act will reduce water demand enough to save local utilities $166 million to $231 million. The savings would result from deferred or avoided investments to expand drinking water treatment operations or storage capacity (Vickers, 2001).

Accelerated installation of high-efficiency plumbing devices, especially 1.6 gallons per flush (gpf) toilets, through incentive programs has become a very cost-effective way for some municipalities to defer, reduce or avoid expansion related capital costs of needed water supply and wastewater facilities. The magnitude of infrastructure savings achievable through incentive programs for toilet replacement is impressive. For example, New York City invested $393 million in a 1.6-gpf toilet rebate program that has reduced water demand and wastewater flow by 90.6 mgd, 7 percent of the city's total water use. The rebate program accomplished a net present value savings of $605 million from a 20-year deferral of water supply and wastewater-treatment expansion projects (Ivanovich, 2001).

In addition to cost efficiency, water-efficient technologies that are also convenient are valued by residential users. A recent survey in Las Vegas found one in every 10 respondents said they never adjust the timer on their lawn sprinkler system to reflect hotter or colder weather, wasting 80 percent of the water. New technology that automatically adjusts the watering times can significantly conserve this wasted water (Sonner, 2003).

Based on survey results, the promotion of water-efficient technology is not widely used in the Great Lakes region. Only two respondents (1.50%) offer rebates for water-efficient technology. Despite the lack of programs subsidizing water-efficient fixtures, 14 respondents (about 10%) foresee using such programs in the future. Although only two respondents replied that they offer rebates, a Canadian database of conservation programs may point to other rebate programs in the region that are not captured by the survey. This database is hosted on Water Efficiency Experience Database web site (http://www.on.ec.gc.ca/wed/search.cfm?Lang=e) by Environment Canada.

Water audits are considered to be a service offered by utilities as components to their water conservation programs. In a water audit, a trained technician surveys the residential home for potential leaks and educates the resident about the installation of efficient devices and other cost-saving methods. Studies have shown that home water audits can result in water savings when plumbing retrofit devices are installed and practical guidance is given about efficient outdoor watering. Water audits have resulted in the potential savings of 20 to 30 gallons per day (Vickers, 2001). About 20 percent of the respondents perform residential or commercial water audits, and 20 percent foresee conducting audits in the future.

Water-Efficient Technology and Services – Water Supply Systems

Water supply facilities use water-efficient technology and services to improve their own operations. Water audits and leak detection help control the loss of water in the system and, ultimately, the resulting loss of revenue. The U.S. Geological Survey estimates that 6 billion gallons per day are lost in the United States, costing an estimated $800 million a year. One of the themes for an AWWA Conference on June 16, 2003, in California was,

"there is no such thing as unaccounted-for water, just non-revenue water." This theme may provide the reason why leak detection and water audits were among the popular conservation activities for facilities in the Great Lakes basin; 69 percent of respondents perform leak detection activities, and 22 percent of respondents conduct water audits. Nearly 70 percent of the survey respondents indicated that lowering water loss in the system is an objective of their conservation program.

Besides economics, state regulation may be another driving force in reducing water loss to the system. Water suppliers in Illinois, Minnesota, New York and Pennsylvania must comply with the regulation requirements of the states' water permitting programs that attempt to minimize the amount of the unaccounted-flow or water loss to a public water supply system. The Illinois Department of Natural Resources requires distribution system owners, or permittees, to report annually the amount of Lake Michigan water used along with the amount lost due to unaccounted-for-flow. If a permittee's unaccounted-for-flow exceeds 8 percent, a plan of action must be submitted explaining how unaccounted-for flow will be brought below the 8 percent standard. Minnesota DNR requires public water suppliers with unaccounted-for water volumes that exceed 20 percent to establish a goal and reduce unaccounted-for water to less than 20 percent within three years. New York's Public Water Supply Permit Program (PSWPP) requires permittees to develop and implement long-term water conservation measures such as metering, meter replacement/ calibration, system water audits, and leak detection and repair. The goal of each program is to keep unaccounted-for water to 15 percent or less. Pennsylvania's Department of Environmental Protection investigates unaccounted-for flows in water systems that exceed 20 percent.

A water audit is an accounting procedure. The purpose of a water audit is to accurately determine the amount of unaccounted-for water in a water distribution system. Unaccounted-for water may be a result from errors in metering, human errors in meter reading or accounting, unauthorized unmetered users, system leaks and reservoir overflow. Unaccounted-for water is calculated from verified supply and consumption records, factoring in various estimated usage figures. The calculation procedures are designed to balance the water supplied to a system with the water legitimately used. After identifying all sources of system inefficiency, water loss, revenue loss, plans are developed to reduce waste and improve system efficiency. Benefits of conducting water audits include:

- Water loss reduction and consequent cost reduction in electrical energy, chemical products, among others
- Increased income with the detection of consumers that are not being billed or are being billed incorrectly
- Improved knowledge of the operating system
- Postponing investment in new water sources
- Improved public relationship
- Reduction in illegal connections

The AWWA and the International Water Association (IWA) have developed standardized methods for accounting for water use and loss in water distribution systems. More

information about these resources is available on their websites: www.awwa.org and www.iwahq.org.uk.

1. The AWWA published a manual in 1999, titled *Water Audits and Leak Detection, M36, Second Edition.* This manual presents step-by-step instructions and sample forms for conducting a comprehensive, systemwide audit and leak detection and repair programs.

2. The IWA published a manual in 2001, titled *Standard Components of Water Balance for Transmission or Distribution Systems*. This manual presents a recommended standard format and terminology.

3. Most recently the IWA has released *Losses in Water Distribution Networks: A Practitioner's Guide to Assessment, Monitoring and Control* in April 2003. This manual takes a diagnostic approach to develop a water loss strategy by identifying appropriate tools that can by applied to any system. Systems and methodologies are presented for improving water loss and leakage management in a range of networks, from systems with a well-developed infrastructure to those in developing countries where the network may need to be upgraded.

Leak detection is an important element to any system water audit. To combat water loss and associated revenue losses, many water systems are developing methods to detect, locate and correct leaks. Across the United States, the water industry seems to accept an unaccounted-for water loss of 10–12 percent as normal, although unaccounted-for water of greater than 30 percent is not uncommon (Wyatt, 2002). Leakage may account for a large portion of the problem. Additional reasons why water systems should adopt ongoing leak detection and repair programs include:

- Leaks get bigger with age.
- Repairing leaks reduces growing water losses.
- Regularly scheduled maintenance reduces overtime costs of unscheduled repairs.
- Leak repairs provide more treated, pressurized water to sell to customers.
- Leak detection and repair can reduce power costs to deliver water and reduce chemical costs to treat water.
- Leaks have been known to cause damage to nearby roads, other infrastructure, and sometimes buildings. Some water utilities conduct frequent leak detection and repair programs near unstable geologic areas to reduce their legal liability against expensive lawsuits.
- Leak detection and repair improves public relations. The public appreciates seeing that its water systems are being maintained.
- The utility gains credibility by managing its own leaks before asking the customers to conserve water.

There are various methods for detecting water distribution systems leaks. These methods usually involve using sonic leak-detection equipment that identifies the sound of water

escaping a pipe. Leaks make noise because the pressurized water forced out through a leak loses energy to the pipe wall and to the surrounding soil area. This energy creates sound waves in the audible range, which can be sensed and amplified by electronic devices. Some additional noise is created by the impact of water upon soil in the area of the leak. Agitated sand and gravel can sometimes be heard striking the pipe. Correlation devices can be used to listen at two points simultaneously to pinpoint the exact location of a leak.

Detecting leaks is only the first step in eliminating leakage. Leak repair is the more costly step in the process. Repair clamps, or collars, are the preferred method for repairing small leaks. Larger leaks may require replacing one or more sections of pipe. On average, the savings in water no longer lost to leakage outweigh the cost of leak detection and repair (Lahlou, 2003).

Concluding Observations

- Water conservation will increase among end users if price appropriately reflects the true value of water.
- Measuring water use by metering service connections is a prerequisite for other conservation measures such as pricing, education and leak detection.
    1. When coupled with public education campaigns and appropriate pricing structures, metering can sensitize end users to the importance of water conservation.
    2. Metered water provides revenue and useful information for water system audits for the utilities.
- The promotion of water efficient technology and services is cost-effective for both the water supply facility and the end user.
    1. End users can save on costs of water and energy when upgrading to new plumbing devices, appliances and lawn watering systems.
    2. Water supply facilities can delay, reduce or avoid expansion-related capital costs of needed water supply and wastewater facilities by reducing water demand.
- Leak detection and repair are some of the most practiced conservation activities by water systems surveyed in the Great Lakes region. Water system audits and leak detection and repair programs will improve the operations of water supply facilities by
    1. Reducing the water loss in the system
    2. Reducing water production costs
    3. Providing more water to sell to end users

Summary Conclusions

After analyzing the survey results and reviewing pertinent literature on water conservation, a few general observations and conclusions about water conservation in the Great Lakes region are noteworthy and are described below:

Water conservation practices are not widely promoted in the region. Most respondents attribute this fact to the perception of adequate water supply. In a few areas in the basin where water supply is a concern, strong water conservation programs are in place to manage water demand.

Water conservation efforts are most prevalent in areas where water demand is projected to increase and the current resources are not adequate to meet future needs. The region of Waterloo, Ontario, for instance, is faced with a depleting groundwater supply and an expected increase in population. Water conservation efforts in this region are strong as a result. The City of Chicago and its surrounding suburbs, as another example, are limited to the amount of water diverted from Lake Michigan. Responding to this reality, the city is installing meters on residential connections that were previously unmetered. When completed, the program will contribute to the water use accounting of Lake Michigan water and regional conservation efforts. Case study examples of innovative water conservation practices in these communities will be developed as a second product under the Great Lakes Commission's water conservation project to provide more in-depth analysis of specific conservation policies and activities; examine the factors that drove water conservation efforts; and explore how they are implemented in the community.

While conservation is not a regional priority among the majority of public water suppliers surveyed, many engage in conservation activities such as water system audits, leak detection and metering that ensure the proper account of water use. Even without the intent to conserve, these activities benefit the overall operations of a water system.

Water systems should take into consideration the view that water conservation is a way of controlling the increase in future demand on their capacity to treat, store and distribute water. Deferring or avoiding the capital costs of the expansion of the system is a strong incentive for water systems to develop water conservation programs. Water conservation activities such as metering, leak detection, appropriate water pricing, public education campaigns and the promotion of water efficient-technology, may have a greater impact on reducing water demand when conducted together rather than separately. The following are concluding observations from each section of the report.

Conservation Planning and Regulations

- The federal policies and initiatives administered through the U.S. EPA and Environment Canada may provide opportunities to apply conservation programs to the Great Lakes region.
- Nearly half of the Great Lakes jurisdictions do promote water conservation through various programs; the most effective programs appear to be those that marry conservation requirements to permitting.

- In general, conservation efforts among local jurisdictions are few; the lack of conservation efforts can be primarily attributed to the perception of adequate or abundant water supplies from all sources of water.
- An accurate assessment of water supplies along with a commitment to conducting forecasts of future water demand may help local municipalities and water utilities apply necessary conservation measures.

Education

- Education programs exist within less than half of the facilities in the Great Lakes region, consisting mainly of bill inserts.
- Survey results indicate that facilities rarely evaluated the success of their education program due to time, staff and financial constraints.
- 70 percent of the respondents predict educational campaigns to be one of the future conservation trends.
- One facility superintendent in Michigan wrote that the education of public officials such as the mayor, council members and board members in water conservation should be a priority in areas where the water supply is inadequate or unreliable.
- Water systems that have active programs involving technical assistance, water surveys, incentives and ordinances may benefit more from a general awareness or education campaign than a system that only implements an education program.

Financial Incentives

- Water conservation will increase among end users if price appropriately reflects the true value of water.
- Measuring water use by metering service connections is a prerequisite for other conservation measures such as pricing, education and leak detection.
    1. When coupled with public education campaigns and appropriate pricing structures, metering can sensitize end users to the importance of water conservation.
    2. Metered water provides revenue and useful information for water system audits for the utilities.
- The promotion of water efficient technology and services is cost-effective for both the water supply facility and the end user.
    1. End users can save on costs of water and energy when upgrading to new plumbing devices, appliances and lawn watering systems.
    2. Water supply facilities can delay, reduce or avoid expansion-related capital costs of needed water supply and wastewater facilities by reducing water demand.
- Leak detection and repair are some of the most practiced conservation activities by water systems surveyed in the Great Lakes region. Water system audits and leak

detection and repair programs will improve the operations of water supply facilities by

1. Reducing the water loss in the system
2. Reducing water production costs
3. Providing more water to sell to end users

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Appendix A
Water Conservation Surveys

Water Conservation Survey

Great Lakes Commission des Grands Lacs

PLEASE RETURN THIS SURVEY BY April 21, 2003.
Note: You may check more than one box for a given question, if appropriate.
Approximate time for completion: 30 minutes. (If a piece of information is not readily available, please estimate or leave blank and move to the next question.)

1. Contact Information

Name/Title: _____ Phone: _____ Fax: _____

Name of Facility: _____ Email: _____

Name of municipalities/unincorporated areas served: _____

_____

City: _____ State: _____

Postal Code: _____ Website: _____

2. Background Information

Is water purchased from another water system? ☐ Yes ☐ No

If **yes,** estimated percentage of purchased water used in your system: ☐ 100% ☐ Other: _____

Identify the sources of water used by your system:
(If purchased water is used, indicate the source of the purchased water)

Source	% of withdrawals from each source
☐ Groundwater	
☐ Great Lakes-St. Lawrence Surface Water	
☐ Lake Superior	
☐ Lake Michigan	
☐ Lake Huron/St. Mary's River	
☐ Lake Erie/St. Clair R./L. St. Clair/Detroit R.	
☐ Lake Ontario/Niagara River	
☐ St. Lawrence River	
☐ Other Surface Water (streams, lakes, reservoirs in the basin)	
Name of surface source:	
☐ Unsure	
Total	100%

Does your system sell water in bulk to other water systems: ☐ Yes ☐ No

If **yes**, what was the approximate quantity sold in 2002? _____ million gallons/day (MGD)

Please answer the following questions, **not** including water sold to other water systems. Approximate figures are fine.

Average daily water use from all sources in 2002: _____ (MGD)

Population served: _____

Residential service connections - % of total demand: ____

Number of service connections: _____

Commercial service connections - % of total demand: ____

Number of service connections: _____

Percentage of service connections that are metered: _____

Annual budget for metering: _____

3. Conservation Programs

What types of conservation activities does the facility employ?

- ☐ Increase percentage of metered connections
- ☐ Leak detection
- ☐ Meter calibration and replacement
- ☐ Water audits
- ☐ Inverted pricing blocks
- ☐ Industrial/commercial/institutional advice
- ☐ Install/subsidize POU low-flow fixtures
- ☐ Consumer education
- ☐ Watering restrictions
- ☐ Other: _____

What are the objectives of the conservation program?

- ☐ Lowering overall water use
- ☐ Drought contingency
- ☐ Lowering water lost in the system
- ☐ Control production costs
- ☐ Other: _____

Do partnerships exist within the community to promote water conservation? ☐ Yes ☐ No

If **yes**, please explain: _____

_____

Approximate annual budget for the program: _____

4. Conservation Planning

Does this facility operate under a formal conservation plan? ☐ Yes ☐ No ☐ Unsure

If **yes,** what factors most influenced the decision to develop a conservation plan?

- ☐ Drought
- ☐ Public interest
- ☐ Poor water quality
- ☐ Groundwater supply concerns
- ☐ System capacity limits
- ☐ Regulatory requirements
- ☐ Projected water demand increase
- ☐ Control production costs
- ☐ Other: _____

If **no,** why has a conservation plan not been developed?
☐ Financial disincentives (Loss in revenues) ☐ Adequate water supply
☐ Lack of public concern ☐ Political obstacles
☐ Other: _____

Does this facility rely on conservation guidelines issued by a governmental agency or some other source involved in water conservation planning efforts? ☐ Yes ☐ No

If **yes,** which guidelines are used?

☐ U.S. EPA ☐ State
☐ Municipal ☐ American Water Works Association
☐ Conservation Authority
☐ Other: _____

Approximate the first year the guidelines were implemented: _____

5. Financial Incentives

What financial incentives for water conservation are offered?
☐ Incentives to improve conservation efforts (e.g., rebates on low-flow fixtures)
☐ Conservation pricing/rate structures (Describe, if checked.) _____
_____
☐ Metering/submetering for industrial customers
☐ Universal metering/submetering for residential customers
☐ Other: _____

Approximate annual budget for the incentives: _____

6. Regulatory and Legislative Approaches

Is water conservation mandated by ordinance/bylaw or regulation? ☐ Yes ☐ No ☐ Unsure

Who issued the regulation or legislation?
☐ Municipality ☐ Township
☐ County

7. Trends in Water Conservation

Over the next ten years, which of the following water conservation activities would this facility most likely pursue?

☐ Increase percentage of metered connections ☐ Industrial/commercial/institutional advice
☐ Leak detection ☐ Install/subsidize POU low-flow fixtures
☐ Meter calibration and replacement ☐ Consumer education
☐ Water audits ☐ Increase watering restrictions
☐ Creation of a formal conservation plan ☐ Inverted pricing blocks
☐ No conservation efforts

☐ Other: _____

8. Consumer Education

Are any education programs on the need for water conservation in place? ☐ Yes ☐ No

If **yes**, check the items below that apply to the education program.

☐ TV/Radio commercials
☐ Newspaper publications
☐ Water bill inserts/stuffers
☐ School programs
☐ Internet
☐ Special mailings
☐ Special events, describe: _____
☐ Other: _____

Approximate annual budget for the education effort: _____

How are these education programs financed?

☐ Government grants
☐ Foundation support
☐ User fees
☐ Water rates
☐ Other: _____

Is the success of the education program evaluated? ☐ Yes ☐ No

If **yes,** what are the methods of evaluation?

☐ Tracking changes in residential water use
☐ Number of hits on a website
☐ Number of emails/phone calls
☐ Requests for educational publications
☐ Encouragement by the public for more events on conservation
☐ Other: _____

If **no**, why isn't program success evaluated?

☐ Time constraints
☐ Budget constraints
☐ Staffing constraints
☐ Other: _____

9. Other

Provide any thoughts or ideas on water conservation and its application in the Great Lakes region:

_____
_____
_____
_____
_____

BE SURE TO SAVE THE SURVEY AFTER COMPLETION

Questionnaire sur la conservation de l'eau

Great Lakes Commission des Grands Lacs

Prière de nous retourner ce questionnaire avant le 21 avril 2003.
NB: Si nécessaire, plusieurs cases peuvent être cochées par réponse.
La durée du questionnaire est approximativement 30 minutes. Si vous ne pouvez pas répondre à la question dans une manière relativement rapide, estimez ou allez à la prochaine.

1. Renseignements vous concernant

Nom de l'interlocuteur/Fonction de l'interlocuteur: _____

Tél: _____Télécopie: _____ Courrier électronique: _____

Nom du réseau:_____

Noms des municipalités desservies: _____

_____

Ville: _____ Code Postal: _____

Site Internet:_____

2. Information complémentaire

Est-ce que l'eau d'une autre municipalité achetée? ☐ Oui ☐ Non

Si oui, estimez le pourcentage d'eau achetée qui est utilisée dans votre réseau:
☐ 100% ☐ Autre : _____

De quelles sources provient l'eau utilisée par votre réseau?
(Si, l'eau achetée est utilisée, indiquez la source de l'eau achetée.)

Sources	**% du retrait total de chaque source**
☐ des eaux souterraines	
☐ des eaux surface des Grands Lacs et du fleuve Saint-Laurent	
☐ Fleuve Saint-Laurent	
☐ d'autres sources d'eaux surface (fleuve, réservoir, ou lac dans le bassin)	
Nom de source :	
☐ Pas sûr	
Total	100%

Votre réseau vend-il l'eau à d'autres réseaux? ☐ Oui ☐ Non

Si **oui**, quelle est la quantité vendue en l'an 2002 [en million de litres/jour (MLD)]? _____

Veuillez répondre à la question suivante, **pas** comprenant l'eau vendue à d'autres réseaux. Estimez les chiffres.

Débit maximal annuel en eau, toutes sources confondues, en l'an 2002 (en MLD):

_____

Nombre de personnes desservies: _____

Consommateurs résidentiels – % de demande en eau: _____

Nombre de consommateurs: _____

Consommateurs commerciaux - % de demande en eau: _____

Nombre de consommateurs: _____

Pourcentage de personnes desservies dont la consommation en eau est effectivement mesurée:_____

Budget annuel pour mesurer la consommation de l'eau:_____

3. Programmes de conservation de l'eau

Quels types d'activités de conservation sont utilisés par le gestionnaire du réseau ?

☐ Augmentation de nombre des consommateurs avec les compteurs d'eau
☐ Offre de conseils aux personnes desservies (secteur commercial/institutionnel/industriel)
☐ Installation de dispositifs économisant l'eau (accessoires et appareils)
☐ Calibrage et remplacement des compteurs d'eau
☐ Audits d'eau
☐ Sensibilisation de la population aux arrosages de la pelouse
☐ Restriction de la consommation ☐ Plus de programmes éducatifs
☐ Structures tarifaires ☐ Détection et colmatage de fuite
☐ Autre: _____

Quels sont les objectifs du programme de conservation ?

☐ Abaissement de perte de l'eau au réseau
☐ Abaissement de l'utilisation de l'eau
☐ Planification des services d'intervention en cas de sécheresse
☐ Contrôle des coûts de production
☐ Autre : _____

Estimez le budget annuel en total pour tous les activités: _____

4. Organisation de projet de conservation

Ce réseau opère-t-il selon un projet officiel de conservation de l'eau? ☐ Oui ☐ Non ☐ Pas sûr

Si **oui**, quels facteurs influencent le plus la décision de développer un projet de conservation ?

☐ Sécheresse ☐ Capacité limitée des conduites
☐ Intérêt public ☐ Exigences réglementaires
☐ Mauvaise qualité de l'eau ☐ Augmentation projetée de la demande en eau
☐ Incertitudes sur les nappes phréatiques ☐ Contrôle des coûts de production
☐ Autre: _____

Si **non,** pourquoi un projet de conservation d'eau n'a pas été développé?
☐ Obstacles financiers (pertes de revenus) ☐ Approvisionnement en eau adéquat
☐ Manque de réponse/intérêt du public ☐ Obstacle politique
☐ Autre: _____

Est-ce que vous utilisez les directives d'organisations gouvernementales ou d'autres organismes qui sont impliqués dans la conservation de l'eau ? ☐ Oui ☐ Non

Si **oui**, quelles directives sont utilisées?

☐ Province ☐ Agence Ontarienne Des Eaux
☐ Municipalité ☐ Réseau environnement
☐ Autre: _____

Date approximative où ces directives ont été appliquées: _____

5. Initiatives financières

Quelles initiatives financières pour la conservation de l'eau sont offertes?
☐ Incitations au moyen de rabais et de crédits fiscaux
☐ Structures tarifaires (Décrivez) _____
☐ Installation de compteurs d'eau pour les consommateurs industriels
☐ Installation de compteurs d'eau pour les consommateurs résidentiels

Estimez le budget annuel en total pour toutes les initiatives financières: _____

6. Initiatives politiques

Est-ce que la conservation de l'eau est exigée par une loi ou un règlement municipal?

☐ Oui ☐ Non ☐ Pas sûr

7. Projection sur l'avenir des activités pour la conservation de l'eau

Au cours des 10 années à venir, quelles activités pour la conservation de l'eau (listées ci-dessous) seront mises en application?
☐ Augmentation de nombre des consommateurs avec les compteurs d'eau
☐ Offre de conseils aux personnes desservies (secteur commercial/institutionnel/industriel)
☐ Installation de dispositifs économisant l'eau (accessoires et appareils)
☐ Calibrage et remplacement des compteurs d'eau
☐ Sensibilisation de la population aux arrosages de la pelouse
☐ Audits d'eau ☐ Création d'un projet officiel de conservation de l'eau
☐ Restriction de la consommation ☐ Plus de programmes éducatifs
☐ Structures tarifaires ☐ Détection et colmatage de fuite
☐ Autre: _____

8. Education du consommateur

Existe-t-il des programmes éducatifs sur la conservation de l'eau? ☐ Oui ☐ Non

Si **oui**, cochez les cases (ci-dessous) qui font parties du programme ?

☐ Publicités à la télévision/radio
☐ Publicité dans journal
☐ Brochures par courrier
☐ Programmes scolaires
☐ Internet
☐ Dépliant joint aux factures d'eau
☐ Evénements publics spéciaux (Décrivez): _____
☐ Autre: _____

Estimez le budget annuel en total pour tous les programmes: _____

Comment ce programme éducatif est financé?

☐ Bourses gouvernementales
☐ Aide d'organismes privés
☐ Amendes
☐ Tarifs pour l'usage de l'eau
☐ Autre: _____

Est-ce que la réussite de programme est évaluée? ☐ Oui ☐ Non

Si **oui,** quelles sont les méthodes d'évaluation?

☐ Suivi des changements d'usage résidentiel de l'eau
☐ Nombre de visiteurs sur site Internet
☐ Nombre d'appels/messages électroniques
☐ Demandes de publications éducatives
☐ Autre: _____

Si **non**, pourquoi la réussite de programme n'est pas évaluée?

☐ Contraintes de temps
☐ Contraintes financières
☐ Contraintes de personnel
☐ Autre: _____

9. Commentaires

Suggestions et idées sur la conservation de l'eau et sur son application dans la région des Grands Lacs:

_____
_____
_____
_____
_____

Appendix B
Mono Lake Example of Water Conservation

The Mono Lake Story: Water Management and Conservation Regime

In 1941, the Los Angeles Department of Water and Power (LADWP) began diverting Mono Lake's tributary streams 350 miles south to meet the growing water demands of Los Angeles. Deprived of its freshwater sources, the volume of Mono Lake was cut in half. Four of Mono Lake's five year-round tributaries were bone dry and the lake began a steady fall that stretched to 45 vertical feet. Salinity more than doubled, shooting upward toward 100 grams per litre, making the lake 2.5 times saltier than the ocean. The lake level before the diversions of Mono Lake's tributary streams was 6,417 feet above sea level. In January 1982, the lake fell to its lowest levels 6,372 feet.

Unable to adapt to these changing conditions within such a short period of time, the ecosystem began to collapse. Islands that were important nesting sites for various bird species became vulnerable to mammalian and reptilian predation. In 1979 water diversions lowered the lake level to a point where a land bridge emerged connecting Negit Island with the mainland. Hungry coyotes made easy prey of gull chicks, and the adults abandoned the island. In addition, birds that depend on the lake during lengthy migratory journeys were threatened. A systematic survey on November 1, 1948, estimated that there still were about 1 million waterfowl visiting the Mono Basin. Throughout the 1970s and 1980s, populations of migratory duck populations at Mono Lake declined 97%. Furthermore, photosynthetic rates of algae, the base of the food chain, were reduced while reproductive abilities of brine shrimp became impaired. Stream ecosystems were also degraded due to lack of water (Mono Lake Committee 2003).

The State of California amended LADWP's licenses to divert Mono basin water. With amended licenses, LADWP would have to take less water from the basin and replace the lost water supplies. The current lake level is 6382.3 feet above sea level (1,946 meters). It is expected to take about 15-20 years to reach 6,392 feet above sea level, the California State Water Board-ordered stabilization level.

Time period	Elevation (feet above sea level)	Exposed Lakebed (areas)	Salinity (grams per litre)
1941 (pre-diversion)	6,417	0	51.3
1982 (lowest recorded)	6,372	18,500	99.4
2002	6,383	10,000	79.6
Stabilization level in 20 years	6,392	6,700	69.3

The Mono Lake Committee works with LADWP to develop replacement water through recycling and conservation projects. These projects produce more than 50,000 acre-feet of water per year, and, with addition funding, will yield as much as 88,000 acre-feet per year by 2015 – enough to make up the lost Mono Lake supplies (Wong et al. 1999). Today the streams of Mono Lake are full of water; the lake is near its highest point in almost 30 years; and the City of Los Angeles has one of the lowest per capita water use levels in the State. As the result of conservation, the city is using over 100,000 acre-feet less than it did in 1990. The level of water use is the same as it was two decades ago, despite a 30% growth in population.

As of result of these conservation efforts and rising water levels, the Lake's ecosystem shows signs of restoration. Today, the majority of California Gulls nest on the small islets neighboring Negit Island's north shore. A few gulls also nest on the Paoha islets, near Paoha's west shore. As of 1999, with the rising lake, gulls began returning to Negit Island, their primary, native nesting grounds. Migratory duck populations are also returning although not at pre-diversion numbers.

The Mono Lake example demonstrates how state policies and local initiatives can restore severely degraded ecosystem. Preventive conservation initiatives, if established early enough may prevent the type of ecosystem degradation described above. Water conservation principles being considered under the Great Lakes Charter Annex implementation process will provide an opportunity to establish a water conservation protocol for new and expanded water withdrawal and use projects.

Appendix C
U.S. Environmental Protection Agency
Water Conservation Guidelines

Selections from U.S. EPA Water Conservation Plan Guidelines

Summary
The U.S. Environmental Protection Agency (EPA) *Water Conservation Plan Guidelines* provide basic, intermediate, and advanced guidelines tailored for progressively larger water systems and increase in complexity. Basic guidelines pertain to water systems serving fewer than 3,300 people, intermediate guidelines pertain to water systems serving between 3,300 and 10,000 people, and advanced guidelines pertain to water systems serving more than 10,000 people. The guidelines give public water suppliers basic information they need to develop water conservation plans.

Compilation of EPA Guidelines

The Safe Drinking Water Act (SDWA, 42 U.S.C. 300j-15), as amended in 1996, requires the United States Environmental Protection Agency (EPA) to publish guidelines for use by water utilities in preparing a water conservation plan. At their discretion, states may require water systems to prepare a plan consistent with the guidelines as a condition of qualifying for a loan under the Drinking Water State Revolving Loan Fund (SRF).

The Basic Guidelines contain five simplified planning steps. The Intermediate and Advanced Guidelines follow nine planning steps (with some variations in the scope of analysis and level of detail requested): Specify Conservation Planning Goals, Develop Water System Profile, Prepare Demand Forecast, Describe Planned Facilities, Identify Conservation Measures, Analyze Benefits and Costs, Select Measures, Integrate Resources and Modify Forecasts, and Present Implementation and Evaluation Strategy.

Level 1 – measures for basic guidelines:
- Universal metering
- Water accounting and loss control
- Costing and pricing
- Information and education

Level 2 – additional measures for intermediate guidelines:
- Water-use audits
- Retrofits
- Pressure management
- Landscape efficiency

Level 3 – additional measures for advanced guidelines
- Replacements and promotions
- Reuse and recycling
- Water-use regulation
- Integrated resource management

The following page shows a composite table of recommended conservation measures for the various levels available in Appendix A of the *Water Conservation Plan Guidelines*.

Measures	Basic Guidlines	Intermediate Guidelines	Advanced Guidelines
Universal Metering (useful for reducing average-day demand and peak demand)	Source-water metering	Fixed-interval meter reading	Test, calibrate, repair, and replace meters
	Service-connection metering and reading	Meter-accuracy analysis	
	Meter public-use water		
Water Accounting and Loss Control (particularly useful for reducing average-day demand)	Account for water	Analyze nonaccount water	Loss prevention program
	Repair known leaks	Water system audit	
		Leak detection and repair strategy	
		Automated sensors/telemetry	
Costing and Pricing (useful for reducing average-day demand and peak demand)	Cost-of-service accounting	Cost analysis	Advanced pricing methods
	User charges	Non-promotional rates	
	Metered rates		
Information and Education (useful for reducing average-day demand and peak demand)	Understandable water bill	Informative water bill	Workshops
	Information available	Water-bill inserts	Advisory committee
		School program	
		Public-education program	
Water Use Audits (useful for reducing average-day demand and peak demand)		Audits of large-volume users	Selective end-use audits
		Large-landscape audits	
Retrofits (particularly useful for reducing average-day demand)		Retrofit kits available	Distribution of retrofit kits
			Targeted programs
Pressure Management (particularly useful for reducing average-day demand)		System-wide pressure management	Selective use of pressure-reducing valves
Landscape Efficiency (particularly useful for reducing peak demand)		Promotion of landscape efficiency	Landscape planning and renovation
		Selective irrigation submetering	Irrigation management
Replacements and Promotions (useful for reducing average-day demand and peak demand)			Rebates and incentives (nonresidential)
			Rebates and incentives (residential)
			Promotion of new technologies
Reuse and Recycling (useful for reducing average-day demand and peak demand)			Industrial applications
			Large-volume irrigation applications
			Selective residential applications
Water-Use Regulation (useful for reducing average-day demand and peak demand)			Water-use standards and regulations
			Requirements for new developments
Integrated Resource Management (useful for reducing average-day demand and peak demand)			Supply-side technologies
			Demand-side technologies

Source: *Appendix A: Water Conservation Measures.* U.S. EPA <http://www.epa.gov/owmitnet/wave0319/append_a.htm> 20 May 2002.

Appendix D
Water Sources of Public Water Supply Facilities Surveyed

Water Sources of Facilties Surveyed

Water Source	Frequency of Facilities
Groundwater	65
Lake Michigan	20
Lake Erie/St. Clair River	9
Lake Superior	4
Lake Huron/St. Marys River	4
Lake Ontario/Niagara River	4
St. Lawrence River	2
Eaton Reservoir	2
Riviere des Outaoais	2
Branch of Ten Mile Creek	1
Fall Creek	1
Fraser Pit	1
Lac Thimault, Lac de la Deur	1
Maumee River	1
Raguette River	1
Red Lake	1
Resevoir Deaudet	1
Riviere aux Chiens	1
Riviere aux Rochers	1
Riviere Becaneouv	1
Riviere Richelieu	1
Saginaw Bay	1
St. James Pit	1
Upper Cuyahoga River	1
Wanapitel River/ Ramsy Lake	1
Young's Pond	1

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