Treating Wastewater

Formerly Indicator # 7065

Overall Assessment

Trend: **Increasing**

Rationale: In the Canadian portion of the basin, the percent of the population served secondary wastewater treatment or higher increased from 90% in 2004 to 95% in 2006 and 99% in 2009.

Lake-by-Lake Assessment

Lake Superior

Trend: Increasing

Rationale: In the Canadian portion of the Lake Superior basin, the percent of the population served secondary wastewater treatment or higher increased from 4% in 2004 to 98% in 2006 and 99% in 2009.

Lake Michigan

Trend: Unavailable

Rationale: Unavailable

Lake Huron

Trend: Undetermined

Rationale: In the Canadian portion of the Lake Huron basin, the percent of the population served secondary wastewater treatment or higher increased from 93% in 2004 and in 2006 to 97% in 2009

Lake Erie

Trend: Increasing

Rationale: In the Canadian portion of the Lake Erie basin, the percent of the population served secondary wastewater treatment or higher increased from 75% in 2004 to 85% in 2006 and 99% in 2009

Lake Ontario

Trend: Increasing

Rationale: In the Canadian portion of the Lake Ontario basin, the percent of the population served secondary wastewater treatment or higher increased from 94% in 2004 to 98% in 2006 to almost 100% (99.8%) in 2009

Purpose

- To measure the proportion of the Great Lakes basin population served by municipal sewage treatment facilities by treatment level which is reflective of the quality of water discharged
- To measure the percent of collected wastewater that is treated (proportion flow bypass)
- To measure the level of municipal treatment provided with respect to current treatment standards
- The Treating Municipal Wastewater indicator is used in the Great Lakes indicators suite as a Response indicator in the Restoration and Protection top level reporting category.

Ecosystem Objective

To reduce the pressures induced on the ecosystem by insufficient wastewater treatment networks and procedures and further progression towards sustainable development.

Measures

1. Percentage of the Great Lakes population served by municipal sewage treatment facilities by treatment levels
2. Percentage of collected wastewater that is released to waters of the Great Lakes basin without treatment (proportion flow bypass)
3. Percentage of wastewater systems achieving provincial/state Great Lakes effluent water quality standards

Only measure 1 will be reported in 2011.

Ecological Condition

Background

Wastewater refers to the contents of sewage systems drawing liquid wastes from a variety of sources, including municipalities, institutions, industry and stormwater discharges. After treatment, wastewater is released as effluent into receiving waters such as lakes, ponds, rivers, streams and estuaries.

Wastewater contains a large number of potentially harmful pollutants, both biological and chemical. Wastewater systems are designed to collect and remove many of the pollutants using various levels of treatment, ranging from simple to very sophisticated. Effluents released from wastewater systems can still contain pollutants of concern, since even advanced treatment systems do not necessarily remove all pathogens and chemicals.

The following constituents, although not necessarily routinely monitored, are mostly associated with human waste and are present in all sewage effluent to some degree:

- biodegradable oxygen-consuming organic matter (measured as BOD)
- suspended solids (measured as total suspended solids (TSS)
- nutrients, such as phosphorus (usually measured as total phosphorus) and nitrogen-based compounds (nitrate, nitrite, ammonia, and ammonium, which are measured either separately or in combination as total nitrogen)
- microorganisms (which are usually measured in terms of the quantity of representative groups of bacteria, such as fecal coliforms or fecal streptococci, found in human wastes)
- sulphides
- assorted heavy metals
- trace amounts of other toxins and chemicals of emerging concern that have yet to be consistently monitored for in wastewater effluents

Municipal wastewater effluent is one of the largest sources of pollution, by volume, discharged to surface water bodies in Canada (CCME 2006). Reducing the discharge of pollution through wastewater effluent requires a number of interventions ranging from source control to end of pipe measures.

The concentration and type of effluent released into a receiving body of water depend heavily on the type of sewage treatment used. As a result, information regarding the level of wastewater treatment is integral in assessments of potential impacts on water quality. In both the United States and Canada, the main levels of wastewater treatment used include primary, secondary, and advanced or tertiary.

In the United States, *pretreatment* of industrial wastewater may be required to reduce levels of contaminants and to remove large debris before the waters are released to municipal treatment systems for regular treatment. U.S. federal regulations require that Publicly Owned Treatment Works (POTW) pretreatment programs include the development of local pretreatment limits for industrial pollutants that could potentially interfere with municipal treatment facility operations or contaminate sewage sludge. The U.S. Environmental Protection Agency (U.S. EPA) can authorize the states to implement their own pretreatment programs as well. Of the eight states that are part of the Great Lakes basin, Michigan, Minnesota, Ohio and Wisconsin currently hold an approved State Pretreatment Program (U.S. EPA 2006a).

In *primary* wastewater treatment, solids are removed from raw sewage primarily through processes involving sedimentation. This process typically removes about 25% to 35% of solids and related organic matter (U.S. EPA 2000).

Secondary wastewater treatment includes an additional biological component in which oxygen-demanding organic materials are removed through bacterial synthesis enhanced with oxygen injections. About 85% of organic matter in sewage is removed through this process, after which the excess bacteria are removed (U.S. EPA 1998). Effluent can

then be disinfected with chlorine prior to discharge to kill potentially harmful bacteria. Subsequent dechlorination is also often required to remove excess chlorine that may be harmful to aquatic life.

Advanced, or *tertiary*, levels of treatment often are used as well and are capable of producing high-quality water. Tertiary treatment can include the removal of nutrients, such as phosphorus and nitrogen, and essentially all suspended and organic matter from wastewater through combinations of physical and chemical processes. Additional pollutants can also be removed when processes are tailored to those purposes.

Levels of Treatment in the United States and Canada

United States

In the United States, secondary treatment effluent standards are established by the U.S. EPA and have technology-based requirements for all direct discharging facilities. These standards are expressed as a minimum level of effluent quality in terms of biochemical oxygen demand measurements over a five-day interval (BOD5), TSS and pH. Secondary treatment of municipal wastewater is the minimum acceptable level of treatment according to U.S. federal law unless special considerations dictate otherwise (U.S. EPA 2000).

Data on the level of treatment utilized in the United States are available from the Clean Water Needs Survey (CWNS). This cooperative effort between the U.S. EPA and the states resulted in the creation and maintenance of a database with technical and cost information on the 16,000 POTWs in the nation. According to the results of the 2000 CWNS, the total population served by POTWs in U.S. counties fully or partially within the Great Lakes basin was 17,400,897. Of this number, 0.7% received treatment from facilities that do not discharge directly into Great Lakes waterways and dispose of wastes by other means, 14.1% received secondary treatment, and 85.3% received treatment that was greater than secondary, making advanced treatment the type used most extensively (Fig. 4). These values do not include a possible additional 12,730 people who were reportedly served by facilities in New York for which watershed locations are unknown within the CWNS database.

Canada

In Canada, the Great Lakes drainage basins are all located in the province of Ontario. Wastewater Treatment Plants (WWTPs) in Ontario also use primary, secondary, and tertiary treatment types. Most of the municipal wastewater produced in the Great Lakes basin portion of Ontario is treated at a secondary level or higher. Figure 1 shows the distribution of population served according to level of treatment. Figure 2 shows the distribution of population served according to level of treatment for each of the Great Lakes basins.

Secondary-mechanical treatment is the most common type of sewage treatment across the Great Lakes basin, as inferred from the distribution data in both Figures 1 and 2. Tertiary treatment is the second most widespread treatment type. This indicates the potential for good to high effluent water quality, but this can only be verified through analysis of regulatory and monitoring programs.

The proportion of the population served secondary treatment or higher has increased in the Great Lakes basin, from 90% in 2004 to 99% in 2009. The data show an increase in the proportion of the population served secondary treatment or higher in each of the Great Lake basins. The large jump in population served secondary treatment or higher in the Lake Superior basin between 2004 and 2006 is due to upgrades to secondary level treatment in Thunder Bay and Sault Ste. Marie.

Condition of Wastewater Effluent in Canada and the United States: Regulation, Monitoring, and Reporting

Canada

The regulatory framework for wastewater treatment in Canada is currently undergoing significant changes. New federal Wastewater Systems Effluent Regulations have been proposed to set national baseline effluent quality standards achievable through secondary treatment or equivalent. The regulations would also take a first step toward managing sewage overflows from combined sewers. The federal government published the proposed Wastewater Systems Effluent Regulations in the Canada Gazette, Part I, on March 20, 2010. The target for Final Regulations to be published in Canada Gazette, Part II, is December 2011. The Regulations deliver on the federal governments commitment under the Canadian Council of Ministers of the Environment (CCME) Canada-wide Strategy for the

Management of Municipal Wastewater Effluent (CCME Strategy) endorsed by all jurisdictions, except Quebec, Nunavut and Newfoundland and Labrador, in February 2009.

In Canada, wastewater treatment levels are tracked through the Municipal Water and Wastewater Survey (MWWS) administered by Environment Canada. The survey collects data on wastewater treatment levels directly from a large sample of municipalities across Canada, with the resulting data stored in a publically-accessible database.

United States
The United States regulates and monitors wastewater treatment systems and effluents through a variety of national programs. The U.S. EPA's Office of Wastewater Management promotes compliance with the Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) permit program. These permits regulate wastewater discharges from POTWs by setting effluent limits, monitoring, and reporting requirements, and they can lead to enforcement actions when excessive violations occur. The U.S. EPA can authorize the states to implement all or part of the NPDES program, and all U.S. states in the Great Lakes region are currently approved to do so, provided they meet minimum federal requirements (U.S. EPA 2006a). This distribution of implementation power can create difficulties, however, when specific assessments are attempted across regions spanning several states.

Large-scale, national assessments of wastewater treatment have been completed in the past using BOD and dissolved oxygen (DO) levels as indicators of water quality. Since DO levels are proven to be related to BOD output from wastewater discharges (increased BOD loadings lead to greater depletion of oxygen and therefore lower DO levels in the water) historical DO records can be a useful indicator of water quality responses to wastewater loadings. According to a national assessment of wastewater treatment completed in 2000, the U.S. Great Lakes basin had a statistically significant improvement in worst-case DO levels after implementation of the Clean Water Act (U.S. EPA 2000). The study's design estimates also showed that the national discharge of BOD_5 in POTW effluent decreased by about 45%, despite a significant increase of 35% in the population served and the influent loadings. This improving general trend supported assumptions made in the 1996 CWNS Report to Congress that the efficiency of BOD removal would increase due to the growing proportion of POTWs using advanced treatment processes across the nation.

Unfortunately, comprehensive studies such as the examples listed above have not been conducted for pollutants other than BODs, and none have been completed to an in-depth level for the Great Lakes region. However, an extensive investigation of the Permit Compliance System (PCS) database is one way an evaluation of wastewater treatment could be accomplished. This national information management system tracks NPDES data, including permit issuance, limits, self-monitoring, and compliance. The PCS database can provide the information necessary to calculate the loadings of specific chemicals present in wastewater effluent from POTWs in the U.S. portion of the Great Lakes basin, providing the relevant permits exist.

Management Challenges/Opportunities
There are numerous challenges to providing adequate levels of wastewater treatment in the Great Lakes basin. These include: facility aging, disrepair and outdatedness; population growth that stresses the capabilities of existing plants and requires the need for more facilities; new and emerging contaminants that are more complex and prolific than in the past; and new development that is located away from urban areas and served by decentralized systems (such as septic systems) that are much harder to regulate and monitor. The escalating costs associated with addressing these challenges continue to be a problem for both U.S. and Canadian municipalities (U.S. EPA 2004, Government of Canada 2002).

Despite demonstrated significant progress in wastewater treatment across the basin, nutrient enrichment, sediment contamination, heavy metals, and toxic organic chemicals still pose threats to the environment and human health. To maintain progress on these issues, and to ensure that current achievements in water pollution control are not overwhelmed by the demands of future urban population growth, governments should continually invest in wastewater treatment infrastructure improvements. In addition, investments are needed to control or mitigate polluted urban runoff and untreated municipal stormwater, which have emerged as prime contributors to local water quality problems throughout the basin (Environment Canada 2004).

WWTPs are challenged to keep up with demands created by urban development. The governments of Canada and Ontario and municipal authorities, working under the auspices of the Canada-Ontario Agreement (COA) Respecting

the Great Lakes Basin Ecosystem, have been developing and evaluating new stormwater control technologies and sewage treatment techniques to resolve water quality problems (Environment Canada 2004). Under COA, Canada and Ontario will continue to build on this work, implementing efficient and cost effective projects to reduce the environmental damage of a rapidly expanding urban population (Environment Canada 2004).

The presence of chemicals of emerging concern in wastewater effluent is another developing issue. Current U.S. and Ontario permit requirements are based on state or provincial water quality laws that are developed according to pollutants anticipated to exist in the community. This means the existence of new potentially toxic substances can be overlooked. For example, even in areas with a high degree of municipal wastewater treatment, pollutants such as endocrine-disrupting substances can inadvertently pass through wastewater treatment systems and into the environment. These substances are known to mimic naturally occurring hormones and may have an impact on the growth, reproduction, and development of many species of wildlife. Additional monitoring for these pollutants and corresponding protection and regulation measures are advised.

Comments from the author(s)

A number of challenges and barriers to the full implementation of this indicator report were encountered during its preparation. Included were:

Population estimates

The actual proportion of the entire population receiving municipal wastewater treatment is difficult to calculate. In Canada, data from the MWWS is used. The MWWS has a high but not complete response rate; the 2009 MWWS collected wastewater treatment levels for an estimated 82% of the population connected to a municipal sewer. In the United States population estimates were compiled by county, and therefore represent a skewed total for the population that actually resides within the boundaries of the Great Lakes watershed. GIS analysis of census data needs to be completed in order to obtain a more accurate estimate of the Great Lakes population.

Data availability

In Canada, three years of data from the Environment Canada MWWS was used. For Canada overall, the 2009 MWWS collected wastewater treatment levels for an estimated 82% of the population connected to a municipal sewer. Prior to 1999, the survey was called Municipal Water Use and Pricing Surveys (MUD/MUP). In 2001, the survey format was changed and the name updated to the Municipal Water and Wastewater Survey (MWWS). The most recent data set for MWWS is for 2009, with the most recent water use report released in 2007. New data from the 2011 MWWS will be available in 2012.

Loadings calculations

Several problems exist in the calculation of effluent loadings. For example, actual effluent flow is not consistently monitored in the United States. Although influent levels are obtainable for every facility, effluent levels might not be comparable, since a substantial volume may be removed during treatment processes. Because effluent flow data are necessary to calculate loadings from concentration values of pollutants, precise estimates of total loadings to Great Lakes waters may be next to impossible to obtain on a large scale without actual effluent flow data.

Consistency in implementation of analysis

Consistent guidelines and practices for the analysis of wastewater treatment in both the United States and Canada would be helpful. In the United States, data were compiled from several different databases, with population information derived from a separate source than effluent monitoring reports. In Canada, data on both population and wastewater treatment is taken from the Environment Canada MWWS. The MWWS data is geocoded, so it can be analyzed at the level of the Great Lakes basin and each individual Great Lake basin.

Consistency in monitoring and reporting

To successfully correlate wastewater treatment quality with the environmental status of the Great Lakes basin, a more organized monitoring program must be implemented. Although wastewater treatment plants provide useful monitoring information, they only report the quality of the effluent at that specific municipality, rather than the overall quality of the Great Lakes. Additionally, differences in monitoring requirements between Canada and the United States make assessments of the quality of wastewater treatment difficult on a basin-wide scale. Implementation of a more standardized, updated approach to monitoring contaminants in effluent and a standardized reporting format and inclusive database, accessible to all municipalities, researchers, and the general public, should be estab-

lished for binational use. The proposed federal Wastewater Systems Effluent Regulations are expected to improve the collection and monitoring of wastewater effluent quality data in Canada.

Automated data processing

Considering all the difficulties encountered while attempting to adequately summarize the vast amount of U.S. effluent monitoring data contained in the PCS database, a logical solution would be an application that could automate accurate calculations. Such an application previously existed that was capable of producing effluent data mass loadings reports from the PCS database, and annual NPDES Great Lakes Enforcement reports were once compiled. However, the application used to calculate loadings was discontinued due to the modernization of the PCS system that is currently underway, and resources have not yet been available to extend the overhaul to this tool. Incorporating this component into the current modernization could take years due to various logistical problems, including the inherent quality assurance issues (James Coleman, personal communication). Despite these problems, the reinstatement of such a tool would solve the data summarization needs presented in this indicator report and could lead to an effective, comprehensive, and time-efficient analysis of pollutant loadings to the Great Lakes from U.S. wastewater treatment plants.

Further development of this indicator

The ultimate development of this progress report into a reportable Great Lakes indicator is necessary and would be possible in the near future if:

- Increased manpower and time could be dedicated to indicator development,
- Revisions were made to the proposed indicator that included a decreased scope, more realistic reporting metrics, and a less-strenuous reporting frequency,
- The data retrieval process were streamlined with appropriate quality controls, and
- A workgroup was created of members that held specific expertise regarding wastewater systems, treatment plant analytical methods, municipal infrastructure, permitting, and who had knowledge of and access to the relevant databases.

Assessing Data Quality

Insert “x” under the statement that best corresponds with each data characteristic

Data Characteristics	Strongly Agree	Agree	Neutral or Unknown	Disagree	Strongly Disagree	Not Applicable
1. Data are documented, validated, or quality-assured by a recognized agency or organization						
2. Data are traceable to original sources						
3. The source of the data is a known, reliable and respected generator of data						
4. Geographic coverage and scale of data are appropriate to the Great Lakes basin						
5. Data obtained from sources within the U.S. are comparable to those from Canada						
6. Uncertainty and variability in the data are documented and within acceptable limits for this indicator report						
Clarifying Notes:						

Acknowledgments

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Information Sources

List of Figures

Last Updated

Canadian information updated for State of the Lakes Ecosystem Conference (SOLEC) 2011.

US data last updated for *State of the Great Lakes 2007* report.

Figure 1 - Percent of Canadian population in the Great Lakes basin served by wastewater treatment type in 2009

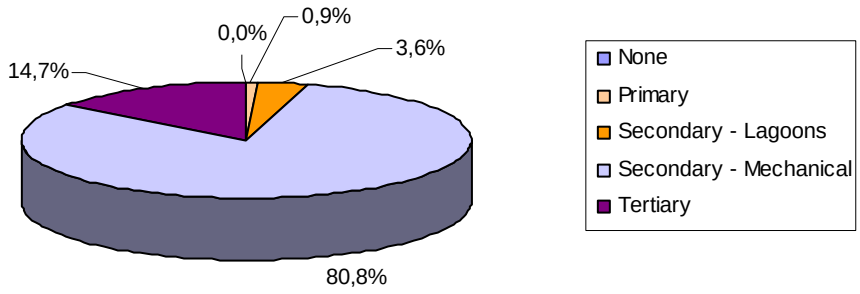


Figure 2 - Percent of Canadian population in each Great Lake basin served by wastewater treatment type in 2009

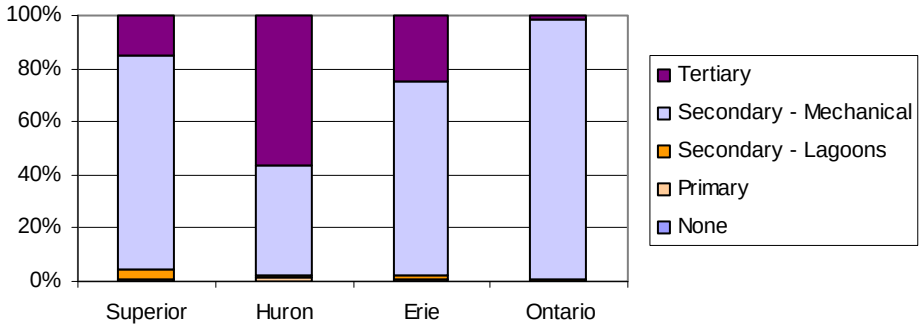
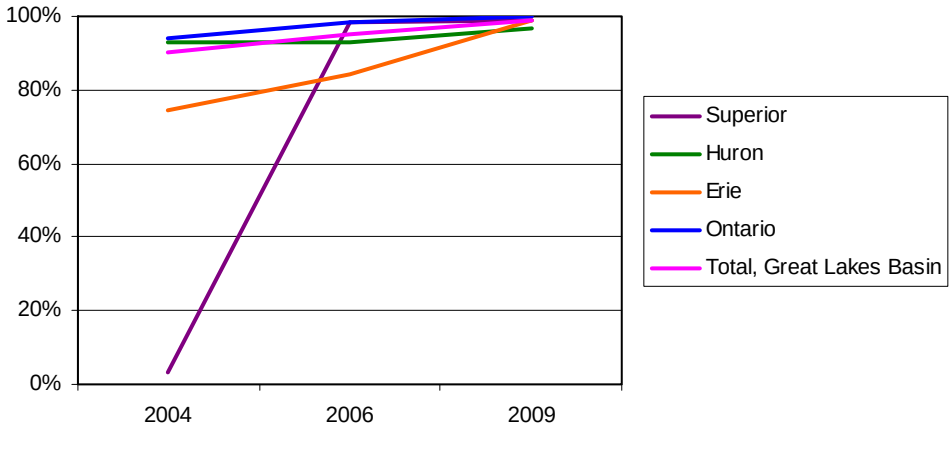


Figure 3: Percent of Population Served Secondary Treatment or Higher, 2004 - 2009



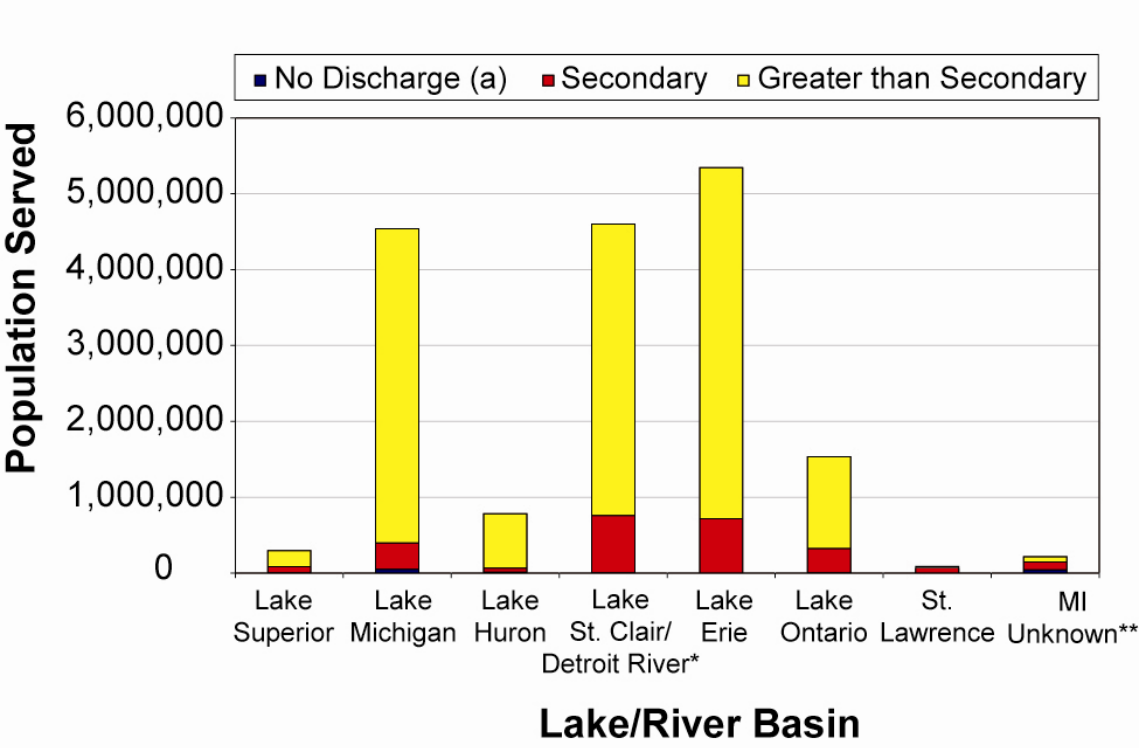


Figure 4. Population Served by Publicly Owned Treatment Works (POTWs) by treatment level in the U.S. Great Lakes basin. (a) = "No discharge" facilities do not discharged treated wastewater to the Nation's waterways. These facilities dispose of wastewater via methods such as industrial re-use, irrigation, or evaporation.
*Lake St. Clair and Detroit River watersheds are considered part of the Lake Erie basin.
** MI unknown refers to the population served by facilities in the state of Michigan for which exact watershed locations are unknown, so the data could not be grouped with a specific lake basin. Population could potentially be distributed between Lakes Michigan, Huron or Erie.
Source: 2000 Clean Watershed Needs Survey