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Canadian Council of Ministers of the Environment | Le Conseil canadien des ministres de l'environnement

Municipal Wastewater Effluent in Canada

Canadian Council of Ministers of the Environment
Municipal Wastewater Effluent Development Committee

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What is municipal wastewater effluent and why is it an issue?

Municipal wastewater effluent consists of *sanitary waste*, collected in sewers and from Canadian households. It also includes waste from industry, commercial establishments, and institutions. Depending on the level of treatment, municipal wastewater typically contains human and other organic waste, nutrients, pathogens, microorganisms, suspended solids, and household and industrial chemicals not removed by the treatment process. In some cases, urban runoff or *stormwater* is collected in the same collection system as sanitary waste, adding different ingredients to municipal wastewater entering wastewater facilities. Collectively, more than 3 trillion litres of treated effluent are discharged each year into Canada's surface water such as lakes, rivers, streams and oceans. The effluent contains a range of contaminants and as a result, has a wide range of potential impacts to environmental and human health.

Typically, municipalities and wastewater facility owners are able to reduce some contaminant levels through treatment of the effluent. Across Canada, wastewater treatment prior to discharge to the environment ranges from no treatment or screening, to state-of-the-art advanced treatment technologies in some of Canada's major centres. But even so, the best available technology today is often not capable of reducing some contaminants.

What's in municipal wastewater and what are the environmental and health impacts of municipal wastewater effluent discharge?

Municipal wastewater effluent is a concern because of its composition and the total volume discharged. Municipal wastewater effluent is commonly comprised of:

- grit, debris, and suspended solids;
- disease causing pathogens such as viruses and bacteria;
- decaying organic waste which reduces the amount of available oxygen in a water body;
- nutrients such as nitrogen and phosphorus; and
- household and industrial chemicals.

A range of typical and emerging contaminants are found in municipal wastewater effluent discharged into the environment. Municipal wastewater effluent is a leading source of biochemical oxygen demand, total suspended solids, nutrients, organic chemicals, and metals contamination. In addition to typical contaminants, newly emerging contaminants such as pharmaceuticals, personal care products, endocrine disrupting compounds and brominated flame retardants are a growing cause for concern.

Typical Contaminants

Biochemical Oxygen Demand refers to the amount of dissolved oxygen in the aquatic environment that is used to break down organic materials in municipal wastewater effluent. The more organic material that is discharged in effluent, the more oxygen is needed to break it down. When aquatic oxygen levels are too low, aquatic organisms are more susceptible to disease, and experience hampered swimming abilities, altered feeding/migration/reproductive behaviours and death.

Total Suspended Solids is organic and inorganic debris suspended in municipal wastewater effluent. High concentrations of total suspended solids impact ecosystems by preventing sunlight from reaching aquatic vegetation and by coating gravel beds where fish spawning occurs. Many chemicals also bind to solids, causing accumulation of toxic compounds in the environment.

Metals are also found in municipal wastewater effluent, although in relatively small quantities, a few milligrams per litre. Aluminum, strontium, and iron are generally the most abundant as often the salts of these metals are used in the treatment process. Present in even smaller quantities (i.e., billionths of a gram) are cadmium, copper, lead, zinc, manganese molybdenum and nickel. Mercury, a metal of considerable environmental concern, is usually present in trace quantities – usually trillionths of a gram. Most metals are removed from the liquid effluent through treatment and end up in the solids generated as a result of wastewater treatment.

Faecal Coliforms are bacteria found in the digestive tract of warm-blooded animals. The level of coliforms in the environment is an indicator of other contaminants such as hepatitis B. Shellfish can become contaminated through filtering faecal coliforms from the water during feeding, which can make humans sick if the shellfish are eaten.

Nutrients primarily refer to phosphorus and nitrogen when considered in the context of wastewater. Nutrients act like a fertilizer and can be beneficial if effluent is properly applied to some crops. Effluent containing high levels of nutrients that is discharged into some surface water may cause an aquatic condition call eutrophication. Eutrophication ultimately leads to a loss of diversity in aquatic plants and animals and overall ecosystem degradation through algae blooms, excessive plant growth, oxygen depletion, and reduced sunlight penetration.

Emerging Contaminants

Historically, *emerging contaminants* have not been thought to be widely distributed within the environment and therefore not a concern. However, numerous contaminants have been found to be persistent, bioaccumulative, and toxic and are now a concern. Among these emerging contaminants are natural and synthetic estrogens, pharmaceuticals, personal care products, surfactants, and flame retardants. These substances have the potential to cause subtle ecological and human health responses at low environmental concentrations. Further study is needed around these emerging contaminants to determine in more detail their long-term effects on environmental and human health, and the optimum point of treatment.

Endocrine disrupting compounds are a wide variety of compounds that exert an array of effects on growth, development and reproduction in wildlife and humans. Examples include natural and synthetic hormones, some pesticides and surfactants, dioxins and furans, DDT and PCBs. Many are chemicals that are in everyday use by industries and households.

Pharmaceuticals and *Personal Care Products* are a diverse group of chemical compounds which include analgesics, lipid regulators, antibiotics, steroids, synthetic hormones, surfactants, musk fragrances, sunscreen agents, and household cleaning and laundry products. Thousands of these chemicals are used annually in Canadian households. Low concentrations of these chemicals have been found in drinking water, surface water, groundwater and municipal wastewater effluent in North America and Europe. The risks of long-term exposure to and consumption by aquatic organisms and humans are unknown.

Brominated Flame Retardants are chemicals used in the textile, furniture, electronic component and building sectors to slow the spread of fire. Brominated flame retardants are persistent organic pollutants that undergo long-range transport and have an affinity for fats. It is unknown how brominated flame retardants are released into the environment and their presence is becoming an increasing environmental concern. They can be found everywhere – water and the aquatic environment, air, soil, birds, as well as humans. They have been detected in human blood, serum, fat tissues, breast milk, placental tissue and the brain. Currently, knowledge about these chemical, their sources, environmental behaviour and toxicity is limited.

Impacts of Municipal Wastewater Effluent

As a result of the complexity of the effluent mix, a broad range of chemical, physical, and biological changes to ecosystems occur, resulting in ecological degradation. Impacts to social (including human health) and economic systems also result. Some of these impacts include:

- Increased moisture and nutrients fro irrigation projects.
- Increased impacts from nutrients and toxic contaminants.
- Increased concentrations of nutrients and toxic contaminants.
- Changes in ecosystem species composition, abundance and diversity.
- Flooding, habitat loss and washout.
- Aquatic oxygen depletion and reduced water clarity.
- Risks to human health through consumption of contaminated drinking water, fish and shellfish, waste on beaches and recreational exposure to contaminated water and sediments.
- Taste and odour problems in drinking water.
- Economic and recreational losses due to restrictions on consumption, reduced fish abundance, changes in fisheries, and reduced aesthetic value of beaches and waterways.

Emerging contaminants have been linked to the following impacts:

- Adverse effects on birds, fish and other wildlife in the Great Lakes Basin possibly include tumours, organ damage, physical deformities, behavioural changes, reproductive disorders and population decline;

- Subtle effects of pharmaceuticals and personal care products have been reported in the development, spawning and other behaviour in shellfish, ciliates, and other aquatic organisms. Detectable levels of pharmaceuticals are below therapeutic levels for humans; however, there are concerns around continual exposure to low levels of pharmaceuticals through drinking water including effects on endocrine, nervous, and reproductive systems, as well as antibiotic resistance;
- Brominated flame retardant contamination is increasing exponentially worldwide and has been linked to thyroid and hormone disruption; and
- Adverse effects on human health are also suspected.

A detailed list of potential impacts can be found in Appendix A.

How is municipal wastewater treated?

The range of municipal wastewater treatment varies across Canada. While data for, municipal wastewater treatment are incomplete, it is estimated that currently 19% of Canadians are served by primary treatment and 38% are served by secondary treatment. Coastal communities are more likely to have either primary treatment or no treatment at all. A high percentage of inland communities have secondary or tertiary treatment.

There are several levels of municipal wastewater treatment applied within Canada: preliminary treatment, primary treatment, secondary treatment, sewage lagoons, tertiary treatment, nutrient removal, advanced or quaternary, and disinfection. Details about the different levels of treatment can be found in Appendix B. Generally, treatment plants are not engineered to remove trace contaminants found at very low concentrations such as part per billion (ug/L). Recent studies have shown a reduction of some specific pharmaceuticals in tertiary, lagoons and secondary treatment systems. However these observed reductions are not readily predictable and tend to be compound specific.

Although *source control* or pollution prevention is not a treatment process, it is a preventative approach to wastewater management that reduces discharge of specific substances to the environment. While not a substitute for treatment of municipal wastewater effluent, source control activities assist in the protection of the sewer or collection system infrastructure, of sewer workers, of the public and of property against hazardous substances potentially released to sewers.

Appendix C provides examples of substances found in wastewater and the effectiveness of each level of treatment in removal of that substance. In general, higher levels of treatment are better able to remove substances from effluent; however, instances where increases in contaminant levels in the discharged effluent have been reported. In some cases, contaminants bind to organics resulting in high concentrations of a particular substance in sludge or biosolids.

While most municipal wastewater facilities employ well established and proven technologies for the removal of typical contaminants (BOD, TSS, nutrients and pathogens), new and *alternative technologies* are constantly evaluated for treatment effectiveness and viability. One example is an *engineered wetland*. Engineered wetlands are examples of a sewage treatment process that can provide additional treatment to a secondary or secondary equivalent (lagoon) facility. Resource recovery from sewage is another alternative use. In Sweden, the United States and parts of Canada, biodiesel is produced from the fat oil and grease collected from sewage. In Sweden and Switzerland, biogas is also being produced. Biogas cogeneration is producing electricity in parts of Sweden, the Greater Vancouver Regional District in British Columbia, and in Lethbridge Alberta. In Japan, sewage-source heat pumps are being used to extract residual heat energy after treatment and before wastewater discharge. Other applications are currently being investigated. The US department of energy is testing direct fuel cells which convert methane to hydrogen internally. The hydrogen is then converted to electricity. Researchers at Pennsylvania State University are investigating a fuel cell which could produce electricity directly from sewage.

How is municipal wastewater effluent managed and regulated in Canada?

Municipal, provincial/territorial, and the federal governments are responsible for managing municipal wastewater effluent in Canada. *Municipalities* are responsible for wastewater management through the statutory mandate to provide wastewater treatment. Additionally, municipalities have the power to control the substances that are discharged into the sewer through sewer use bylaws. Sewer use bylaws help reduce the levels of industrial chemicals of the effluents and establish source control.

Provincial and territorial governments are responsible for the regulation of wastewater treatment operations. Most have waste control statutes that apply directly to the discharge of municipal wastewater effluent. Approved permits by the province/territory are required by all operators of wastewater systems. In addition to waste regulations, permits specify wastewater facility maintenance and treatment requirements and discharge limits for specific substances found in municipal wastewater.

Currently, there is no federal legislation directly pertaining to the discharge of municipal wastewater effluent. The Federal Government does however enforce both the *Fisheries Act* and the *Canadian Environmental Protection Act (1999)*. The *Fisheries Act* protects Canadian waters against the deposit of deleterious substances into fish habitat. The *Canadian Environmental Protection Act (1999)* governs the release of toxic substances into the environment and enables regulations to control or eliminate use of these substances.

What are governments in Canada doing about municipal wastewater effluent?

In 2003, the federal, provincial, and territorial governments in Canada, under Canadian Council of Ministers of the Environment, agreed to work collaboratively to develop a Canada-wide strategy for the management of municipal wastewater effluent. The proposed strategy will focus on improving management within the wastewater sector to improve environmental and human health protection. The proposed strategy will also provide a harmonized and collectively agreed-to regulatory framework for municipal wastewater effluent management in Canada. The strategy addresses issues related to both the performance and the governance of the wastewater sector in Canada. One of the main outcomes of the strategy is to reduce the risks to human health and the environment posed by municipal wastewater effluent contaminants. Information on the strategy and its development can be found on the CCME website, www.ccme.ca.

Where is more information found?

More detailed information can be found on the following websites::

- Environment Canada – http://www.ec.gc.ca/etad/default.asp?lang=En&nav=07A1FB5C-11, http://www.ec.gc.ca/soer-ree/English/soer/MWWE.cfm.
- CCME – www.ccme.ca.
- EPA – http://www.epa.gov/ebtpages/watewastewater.html.
- Alternative technologies – http://collections.ic.gc.ca/western/bearriver.html.
- Emerging Substances – http://www.crd.bc.ca/es/documents/SETACCRDFinalReportv2_000.pdf#view=Fit and http://www.crd.bc.ca/es/documents/panelappendices2006.pdf#view=Fit.

Bibliography

Braghetta, A.H., Gillogly, T., Brownawell, B. and Benotti, M. (2002). *Removal of Pharmaceuticals and Endocrine Disrupting Compounds through Advanced Wastewater Treatment Technologies. Proc. Water Quality Technology Conference*, American Water Works Association (CD-ROM). Denver CO.

Canadian Council of Ministers of the Environment (CCME). (2006). Science and Research on Municipal Wastewater Effluent. Unpublished paper.

Environment Canada. (2001a). *The state of municipal wastewater effluents in Canada*. Retrieved July 21, 2006 from http://www.ec.gc.ca/soer-ree/English/soer/MWWE.pdf.

Environment Canada. (2001b). *Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada*. National Water Research Institute, Burlington, Ontario. NWRI Scientific Assessment Report Series No. 1. 72 p.

Hydromantis Inc., and the University of Waterloo, Department of Civil Engineering. (2005). *Review of the State of Knowledge of Municipal Effluent Science and Research. Final Report – Tasks 2 and 3: Review of Existing and Emerging Technologies and Review of Wastewater Treatment Best Management Practices.* A report prepared for the Canadian Council of Ministers of the Environment.

Lishman L, Smyth SA, Sarafin K, Kleywegt S, Toito J, Peart T, Lee B, Servos M, Beland M, Seto P. (2006). Occurrence and reductions of pharmaceuticals and personal care products and estrogens by municipal wastewater treatment plants in Ontario, Canada. Sci. Tot. Env. 367: 544-558.

Metcalf and Eddy. 2003. Wastewater Engineering: Treatment and Reuse, 4th ed. McGraw Hill, Toronto, Ontario.

Salter, S. (2006). *Treatment Through Resource Recovery: Options for Core Area Sewage*. Unpublished report prepared for the SETAC Review Panel, Capital Regional District Liquid Waste Review.

Sierra Legal Defence Fund. (2004a). *Backgrounder: Sierra Legal National Sewage Report Card.* Retrieved July 21, 2006 from http://www.sierralegal.org/m%5Farchive/bgr04%5F09%5F08.html.

Sierra Legal Defence Fund. (2004b). *The National Sewage Report Card: Grading the Sewage Treatment of 22 Canadian Cities*. Retrieved July 21 from http://www.sierralegal.org/reports/sewage_report_card_III.pdf.

Stubblefield, W. A., Servos, M., Gersberg, R. M., Riley, C., Simpson, D., Smith, D., Wells, P. (2006). *Scientific and Technical Review, Capital Regional District Core Area Liquid Waste Management Plan.* A report prepared for the Capital Regional District, Victoria, BC. Retrieved July 28, 2006 from http://www.crd.bc.ca/es/documents/SETACCRDFinalReportv2_000.pdf#view=Fit and http://www.crd.bc.ca/es/documents/panelappendices2006.pdf#view=Fit.

Appendix A Potential Effects of Municipal Wastewater Effluent Discharge

Ecological Effects – Water and Sediment Quality	• Increases in concentrations of nutrients (nitrogen and phosphorus), toxic contaminants • Oxygen depletion due to decay of plant materials • Reduced water clarity • Bank and stream/river-bed erosion resulting in increased levels of suspended solids • Flooding and habitat washout • Sedimentation related to changes in water flow • Reduced dissolved oxygen levels • Increase in ambient water temperatures • Reduced aesthetics • Increased pathogen concentrations
Ecological Effects – Plants	• Changes in species composition, abundance and diversity • Increased submerged weed growth • Increased number of algae blooms which are sometimes toxic • Bioaccumulation of toxic contaminants/substances
Ecological Effects – Animals	• Changes in species composition, abundance and diversity • Changes in food supplies • Fish kills, reduced species productivity and survival • Impaired reproduction and development, deformities and embryo mortality • Bioaccumulation and biomagnification of toxic contaminants • Depressed thyroid and immune functions in fish-eating birds • Feminization of make fish and reptiles • Loss of habitat and washout • Downstream drift of bottom-dwelling invertebrates • Blanketing of spawning grounds • Blocking of migration/dispersal routes by accumulated sediments • Succession from cold water to warm water fishery • Increased concentrations of pathogens in filter-feeding shellfish
Human Health Effects	• Health risks from consumption of contaminated drinking water, fish and shellfish • Taste and odour problems in drinking water • Health risks from waste on beaches • Health risks from recreational exposure to contaminated water and sediments
Social/Economic Effects	• Blocking of water intakes by algae/weeds • Interference of boat passage from weeds • Restricted and impaired recreational use • Economic loss due to closures of beaches and shellfish growing/harvesting areas (contaminated shellfish) • Economic and recreational losses due to restrictions on consumption, reduced fish abundance, changes in fisheries • Loss of tourism revenue due to reduced aesthetic value • Increased beach and park maintenance costs

Source: Environment Canada, 2001a

Appendix B Levels of treatment of Municipal Wastewater Effluent in Canada

Preliminary treatment involves screening, shredding or grinding for the purpose of removing coarse solids such as sticks, rags and other debris from the incoming wastewater. The purpose of preliminary treatment is to protect downstream treatment components such as pumps and reduce maintenance or operational problems. Preliminary treatment is a common first step to all wastewater facilities

Primary treatment follows preliminary treatment and involves the use of primary devices that allow flows to be reduced and for solids to settle due to gravity. Commonly, sedimentation tanks that detain flows for 2 to 6 hours to allow settleable solids to settle and be drawn off for separate solids treatment. Typical biochemical oxygen demand and total suspended solid removal rates in primary treatment are 30% and 60%, respectively. On stand alone primary treatment, primary effluents can be treated with chemical disinfection prior to release. Primary treatment can also be enhanced using chemicals in which inorganic or organic flocculants are introduced into the wastewater to help improve the effluent quality over primary treatment alone.

Secondary treatment follows primary treatment and is specifically designed for the removal of biodegradable organic matter (in solution or suspension) and the removal of suspended solids. Secondary treatment can include nutrient removal. Typical municipal wastewater effluent quality achieved is a carbonaceous biochemical oxygen demand and total suspended solids of 15 mg/L. The physical, chemical and biological processes in the process design may also fortuitously (not by design) remove other trace contaminants at unpredictable levels.

Sewage lagoons are one of the more common biological treatment processes used in Canada principally due to low cost and simplicity of operation. Effluent quality from lagoon systems varies depending on the type, size and configuration of the treatment cells (i.e. anaerobic cells, facultative cells and storage cells) and operational mode (i.e., seasonal or continuous discharge mode). A lagoon system with several months of storage capacity, such as systems with once a year discharge, can consistently produce very good effluent quality if the biological activity is not hindered. Recognizing that effluent quality varies with the size, type, configuration and retention time, a range of municipal wastewater effluent quality can be achieved for carbonaceous oxygen demand of 5 to 25 mg/L and for total suspended solids of 10 to 30 mg/L.

Tertiary treatment is defined as the additional treatment needed to remove suspended, colloidal, and dissolved constituents remaining after conventional secondary treatment. In Canada this term can refer to physical processes that further remove suspended solids, such as sand filtration. Tertiary treatment may include biological processes for removal of nutrients. Typical tertiary effluent carbonaceous biochemical oxygen demand and total suspended solid values are 5 and 5 mg/L. The movement of trace contaminants and metals from the liquid to the solid streams is generally enhanced due the additional processes which are involved.

Nutrient removal refers to treatment steps used to remove nitrogen and phosphorous from municipal wastewater effluent. Common types of nutrient removal treatment methods include nitrification (conversion of ammonia to nitrates), denitrification (conversion of nitrates to nitrogen gas), biological excess phosphorous removal and chemical phosphorous removal. Nutrient removal processes are commonly incorporated into either secondary or tertiary treatment for enhanced removal of nitrogen, phosphorous or both to protect sensitive receiving environments. Typical wastewater facilities with nutrient removal can achieve municipal wastewater effluent concentration levels of total phosphorous down to 0.1 mg/L, total ammonia-nitrogen down to 5 mg/L in winter and less than 1 mg/L in summer.

Advanced or Quaternary *treatment* refers to the treatment processes that are used to further enhance the quality of MWWE beyond that produced by tertiary treatment. This level of treatment is required where enhanced source water protection is required or for water reuse applications. Advanced treatment technologies include reverse osmosis, membrane filtration, and activated carbon technologies.

Disinfection of municipal wastewater effluent is typically accomplished by using appropriate dosages of chlorine, hypochlorite or ultraviolet (UV) radiation. Disinfection systems are designed to achieve low levels of indicator microorganisms such as *E. coli* in the range of 100 counts per 100 mL.

Appendix C Categorization of Wastewater Substances by Process Treatment

Substance	Treatment Technology						
	Primary Treatment	Facultative Lagoon	Secondary non-nitrify	Advanced Secondary	Tertiary		
					Nitrify + filter	BNR	Nitrify CAS + RO
2,4-D	Poor(6)	Moderate	Poor(6)	Poor(6)	Poor(6)	Poor(6)	Good
Aluminum	Moderate	Poor(5)	Moderate	Moderate	Good	Good	Excellent
Ammonia	Poor	Excellent	Moderate	Excellent	Excellent	Excellent	Excellent
Anthracene	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Antimony(1)(7)	Poor	Poor	Moderate	Moderate	Moderate	Moderate	Excellent
Arsenic(1)	Poor	Poor	Poor	Poor	Poor	Poor	Good
Benzo(a)anthracene	Moderate	Excellent	Good	Excellent	Excellent	Excellent	Excellent
Benzo(a)pyrene	Moderate	Excellent	Good	Excellent	Excellent	Excellent	Excellent
Bis(2-ethylhexyl)phthalate	Poor	Excellent	Good	Good	Good	Excellent	Excellent
Cadmium	Poor	Poor	Poor	Poor	Good	Moderate	Excellent
Chlordane	Poor(6)	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Chloroform	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Chlorophenol	Poor	Excellent	Moderate	Moderate	Good	Good	Excellent
Chromium (hexavalent) Chromium (trivalent)	Moderate	Moderate	Moderate	Good	Excellent	Good	Excellent
Copper	Poor	Poor	Moderate	Moderate	Moderate	Moderate	Excellent
Cyanide (1)	Poor(2)	Moderate	Moderate(2)	Moderate(2)	Moderate(1)	Moderate(1)	Excellent
DDT	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Dichlorobenzene (1,2-)	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Dichloroethane (1,2-) (7)	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Dichlorophenol (2,4-)	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Di-n-butyl phthalate	Poor	Excellent	Good	Good	Good	Excellent	Excellent
Endosulfan	Poor(6)	Excellent	Poor(6)	Poor(6)	Poor(6)	Poor(6)	Good
Ethylbenzene (7)	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Fluoranthene	Poor	Excellent	Good	Excellent	Excellent	Excellent	Excellent
Fluorene	Moderate	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Fluoride (1)	Poor	Poor	Poor	Poor	Poor	Poor	Good
Iron (1)	Moderate	Moderate	Good	Good	Good	Good	Excellent
Lead	Poor	Poor	Poor	Poor	Poor	Poor	Excellent
Lindane	Poor(6)	Excellent	Poor(6)	Poor(6)	Poor(6)	Poor(6)	Good
Magnesium (1)	Poor	Poor	Poor	Poor	Poor	Poor	Good
MCPA	Poor	Moderate	Poor	Poor	Poor	Poor	Good
Mercury	Moderate	Poor	Moderate	Moderate	Moderate	Good	Excellent
Nickel	Poor	Poor	Poor	Poor	Poor	Poor	Excellent
Nitrate(1)	Poor	Poor	Poor	Poor	Poor	Excellent	Good
Nonylphenol	Poor	Excellent	Good	Good	Good	Excellent	Excellent

Appendix B cont'd

Substance	Treatment Technology						
	Primary Treatment	Facultative Lagoon	Secondary non-nitrify	Advanced Secondary	Tertiary		
					Nitrify + filter	BNR	Nitrify CAS + RO
Nonylphenol ethoxylate[1]	Poor[4]	Excellent	Excellent	Excellent[1]	Excellent	Excellent	Excellent
pH	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Phenols, Total	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Phosphorus (total)[1]	Poor	Good[3]	Good	Good	Excellent	Excellent	Excellent
Pyrene	Poor	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Quinoline	Poor	Excellent	Moderate	Good	Good	Good	Excellent
Selenium	Poor	Poor	Poor	Poor	Poor	Poor	Good
Silver [1]	Moderate	Good	Good	Good	Good	Good	Excellent
Sulphide (as H_2S)	Poor	Excellent (Summer) Poor (Winter)	Excellent	Excellent	Excellent	Excellent	Excellent
Tetrachloroethylene	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Toluene	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Trichlorophenoxyacetic acid (2,4,5-)	Poor[6]	Moderate	Poor[6]	Poor[6]	Poor[6]	Poor[6]	Poor[6]
Zinc	Poor	Poor	Poor	Poor	Poor	Poor	Excellent

Indicates substances that may be appropriate for source control

Indicates substances with poor removal that are not recommended for source control

Estimate of removal efficiencies from TOXCHEM+ fate software (Hydromantis, Inc.) unless note (1)

Poor: <50 % removal efficiency

Moderate: 50-74 % removal efficiency

Good: 75-94 % removal efficiency

Excellent: ≥ 95 %removal efficiency

(1) based on professional judgment

(2) EPA (1982)

(3) assumes chemical phosphorus removal

(4) Giger et al, 1987

(5) added to wastewater for phosphorus removal in some treatment facilities

(6) source now are probably diffuse (e.g. applications from old stockpiles, or atmospheric deposition): recommend educational program for homeowners with stockpiles

(7) in absence of CCME or EPA aquatic benchmark, substance was included based on exceedance of Canadian Drinking Water Guideline values

Source: Hydromantis Inc. and the University of Waterloo, Department of Civil Engineering, 2005.