# Examination report by independent experts on the technical and scientific information regarding the planned discharge of untreated wastewater effluent into the St. Lawrence by the City of Montréal

**Daniel Cyr**
**Robert Hausler**
**Viviane Yargeau**

October 30, 2015

Examination report by independent experts on the technical and scientific information regarding the planned discharge of untreated wastewater effluent into the St. Lawrence by the City of Montréal.

Cat. No.: En154-80/2015E-PDF

ISBN: 978-0-660-03783-7

Please note that this report was written by independent experts in the field based on external information not under the control of the Department of Environment Canada. The information, data, recommendations and conclusions contained in the Report represent the consultants' professional judgement in light of the information received; consultants' opinions, recommendations and conclusions might not reflect the Department of Environment Canada's views on the subject matter.



Environment Canada
Inquiry Centre
10 Wellington Street, 23rd Floor
Gatineau QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-997-2800 Fax: 819-994-1412
TTY: 819-994-0736
Email: enviroinfo@ec.gc.ca



Aussi disponible en français.

# Table of Contents

# Mandate

On October 18, 2015, Environment Canada hired three experts, Daniel Cyr, a Professor at the Institut National de la Recherche Scientifique – Institut Armand Frappier (INRS-IAF), Robert Hausler, a Professor in the Department of Construction Engineering at the Écoles des Technologies Supérieures (ETS) and Viviane Yargeau, a Professor in the Chemical Engineering Department at McGill University, to prepare an examination report on the technical and scientific information regarding the planned discharge of untreated wastewater effluent into the St. Lawrence River by the City of Montréal.

To support the committee's mandate, Environment Canada provided the experts with a compilation of information provided by the City of Montréal, the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC) (department of sustainable development, the environment, and the fight against climate change), as well as from various other scientific groups and other community stakeholders. The analysis was conducted based on those documents, a list of which is provided in Appendix 1.

As part of this mandate, the experts had to answer four questions listed in Figure 1. These questions therefore set the parameters for the committee's work and oriented the analysis summarized in this report. The sole purpose of this analysis is to provide decision-makers with an additional source of information from independent scientists.

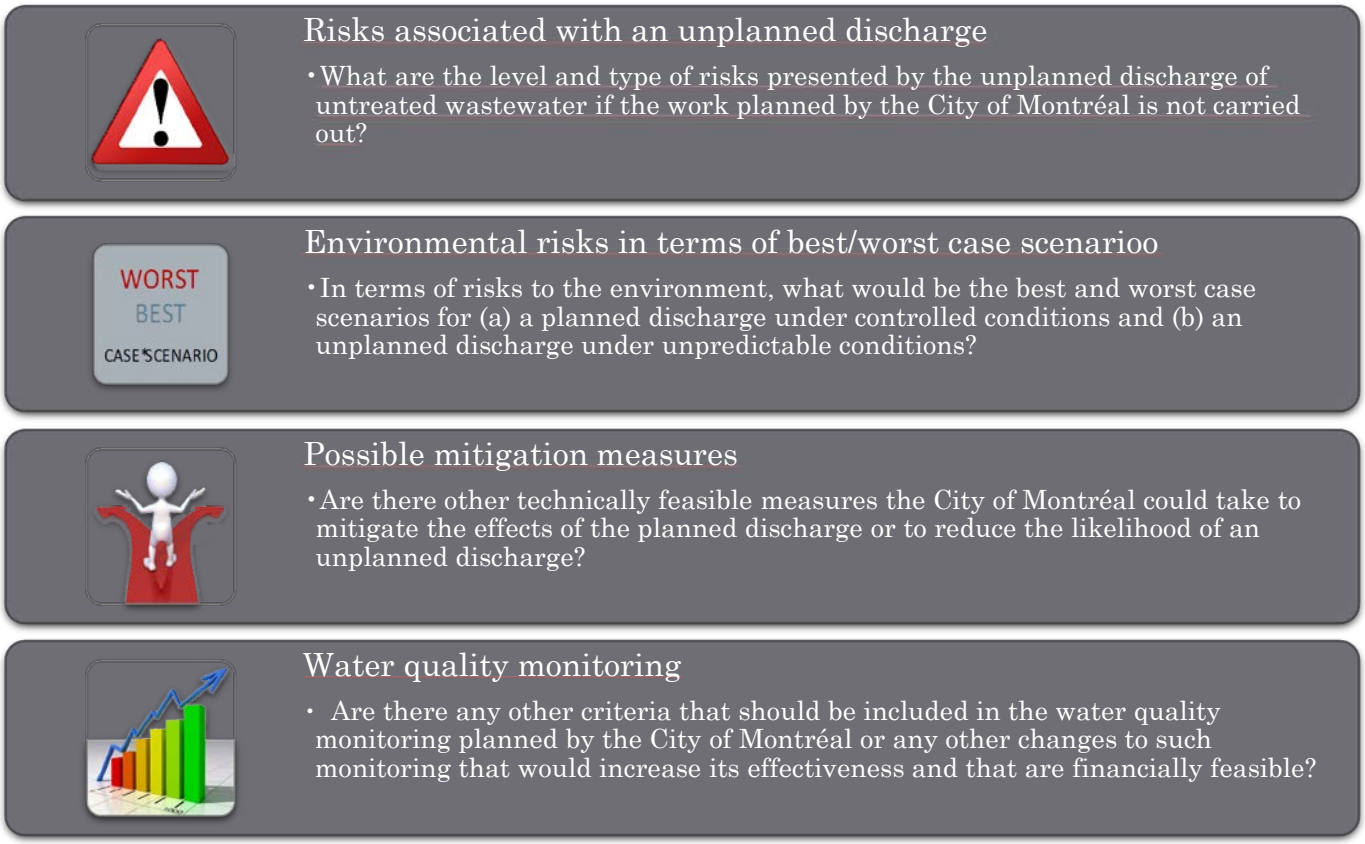



*Figure 1. List of questions defining the framework for the expert committee's mandate*

# Background

## Background on the Work

The Service des infrastructures, de la voirie et des transports (infrastructure, highways and transport department), in collaboration with the Service de l'Eau (water department) at the City of Montréal has indicated that they need to undertake major maintenance work on the main sewer network, i.e. the Southeast Interceptor (see Appendix 2 for the location), as well as the construction of a snow dump. This work is divided into three components:

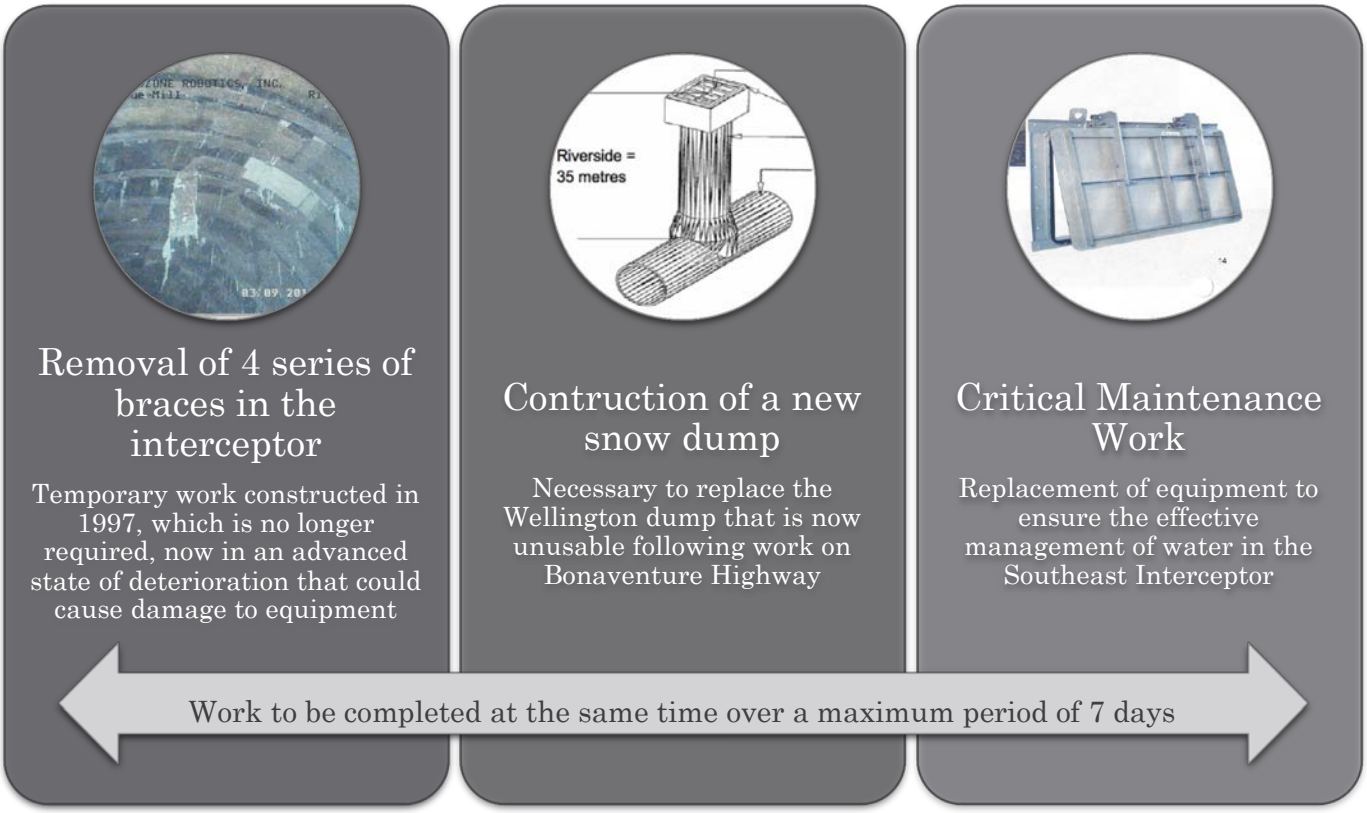



*Figure 2. Summary of the work planned on the City of Montréal's wastewater and snow collection infrastructure*

## Discharge of Wastewater

### Contaminants Present in Untreated Wastewater

The scope of the discharge of environmental contaminants contained in the City of Montréal's wastewater that will be released into the St. Lawrence has not been precisely defined. Based on the documents provided by the City of Montréal, current wastewater treatment results in a significant reduction in suspended solids and phosphorus. However, metal levels are reduced by 20 to 60% and pharmaceutical products and emerging contaminants are not reduced by very much. These treatment levels suggest that part of the wastewater would cause effects similar to what is found downstream from the current treated water discharge location, but with a higher concentration of metals (Cd, Cu, Ag and Zn) (Marcogliese *et al*. 2015a) and an increased presence of suspended solids. Furthermore, it must be taken into consideration that fat-soluble substances found in fat are currently removed in the City of

Montréal's wastewater treatment process and they can be found in the suspended solids that are usually precipitated. Wastewater contains, among other things, several fat-soluble contaminants such as polychlorinated biphenyls (PCBs), estrogens, and polycyclic aromatic hydrocarbons (PAHs) (Pham *et al.* 1999). When untreated wastewater is discharged, these contaminants and pharmaceutical products are released into the river. However, there is no information currently available on the profile of fat-soluble contaminants present in the fat of the effluent or their concentrations. The effectiveness of the primary treatments in removing fat-soluble products varies greatly. For highly fat-soluble contaminants, such as PCBs, certain treatments remove 50 to 75% of the products (Garcia *et al.* 1984). For estrogens, various studies report removal levels between 80-85% (Ternes *et al.* 2007; Andersen *et al.* 2003; Johnson and Sumpter 2001). Since information on the chemical composition of the suspended solids in the City of Montréal's effluent is not available, caution must be taken in evaluating their toxicity.

## Effects of Treated Wastewater on the Receiving Environment

There have been several studies on the chronic effects of treated wastewater on aquatic wildlife and plants in the receiving waters of the St. Lawrence. A summary analysis of the effects reported in scientific literature has recently been published (Marcogliese *et al.* 2015).

The St. Lawrence River contains a rich diversity of fish species in complex ecosystems (Bernatchez and Giroux 2012). The bioaccumulation of contaminants in fish generally dropped in the St. Lawrence between 1976 and 1997 (Laliberté 2003). Furthermore, certain studies report that the contaminant levels in fish captured in Lake Saint-Pierre are lower than in Lake Saint-François, which is upstream from the Island of Montréal (Ion *et al.* 1997; Ion and Lafontaine 1998; Laliberté 2011). However, recent studies have reported the bioaccumulation of polyvinyl methyl ether in perch and muskellunge and perfluorinated products such as perfluorooctanesulfonic acid in northern pike. These products would come from wastewater from Montréal and demonstrate that, although there has been a decrease in the bioaccumulation of classic contaminants, other emerging contaminants are accumulating in the ecosystem's organisms (Houde *et al.* 2013; Houde *et al.* 2014; Laliberté 2011).

Several laboratory studies, *in vivo* and *in vitro*, as well as field studies on cells, bivalves and fish, have made it possible to identify the risks associated with Montréal's treated wastewater. The majority of these studies were conducted on effluents at dilution rates between 1 and 30%. This is comparable to the dilution level of 1% (1 part wastewater in 100 parts river water) expected when assuming that wastewater mixes with only 10% of the river flow. Greater dilution is possible when mixing with the river water as a whole.

Studies have reported that wastewater collected 8 km downstream from the treatment plant has been causing cytotoxicity in cells and inducing the production of metallothionein (MTN) and the enzyme CYP1A1 (cytochrome P450 1A1) (Gagne *et al.* 1995). These results indicate that class II metals and organic contaminants, after dilution over 8 km downstream from the discharge point, had acute toxicity potential. Furthermore, studies by White *et al* (White *et al.* 1996) on bacteria report that treated wastewater is a significant source for genotoxic products. Gagné *et al.* (2011) drew similar conclusions following experiments exposing bivalves to concentrations of treated water similar to those observed near the discharge site of wastewater treated by the treatment plant.

Studies involving acute exposure for 96 hours in a pool of bivalves exposed to treated wastewater revealed immunotoxic effects with a significant loss of immunocompetence (Blaise *et al.* 2002). Similar effects were reported following longer exposure (62 days) (Blaise *et al.* 2002). In the field, bivalves downstream from Montréal are showing the effects of exposure to estrogenic products with an induction of vitellogenin and a higher ratio of females over males (Gagné *et al.* 2010).

Several laboratory and field studies on exposure have reported that the exposure of various fish species to treated wastewater from Montréal's wastewater treatment plant causes an imbalance in the immune systems of fish. These effects are not only due to the toxic products present in the effluent, but also to exposure to microbiological organisms. Some studies have reported that effects manifest within the first few weeks following exposure to concentrations as low as 1% (v/v) of effluent dilution (Salo *et al.* 2007). At that concentration, cytotoxic effects on the immune cells of the pronephros of rainbow trout were observed after only one week of exposure. In addition to the effects on the immune system, effects were noted on minnows downstream from the wastewater treatment plant. These fish showed an induction of vitellogenin, intersex and a delay in the sexual development of males. However,

the induction of vitellogenin requires chronic exposure to wastewater effluent and suggests that effects on the reproduction systems of fish require longer exposure.

### Effects of Untreated Wastewater in the Receiving Environment

Overall, several studies indicate that acute and/or chronic exposure to treated wastewater from the Montréal plant, like many other wastewater treatment plants, can cause negative effects on the physiology of bivalves and fish. It must be believed that this treated wastewater has a toxicity similar to the aqueous part of untreated wastewater (without suspended solids). There are still no studies on the acute or chronic effects of effluent (untreated wastewater) on the aquatic wildlife in the St. Lawrence. It is therefore difficult to predict the risk associated with this exposure to untreated wastewater containing fat-soluble compounds that are normally partially eliminated at the wastewater treatment plant. The LC50 results reported by the City of Montréal suggest that the untreated wastewater has no acute toxicity and is therefore not fatal over the short term.

There is little likelihood that the discharge of effluent into the St. Lawrence will have an effect on fish reproduction since, as indicated in the MDDELCC report, the period targeted for the discharge corresponds to a time of year when the fish are not spawning and it is before the start of the gametogenesis of fish that will be spawning in the spring. However, if the period were moved towards winter during the gametogenesis period of the fish, this could have significant consequences on the reproductive success of the fish. Studies by Schultz *et al.* (2002) have demonstrated that acute exposure to estrogens just before the spawning period of rainbow trout has significant consequences on the fertility of the males. Even if the discharge takes place in the fall, efforts must nonetheless be made to ensure that sediment does not accumulate in the fish spawning areas in order to avoid causing a longer-term increase in toxicity that could have consequences on the reproduction success and development of fish over the years following the discharge of the effluent. This is especially the case in the channel between Ile des Soeurs and Montréal, where there are spawning grounds for several species (northern pike, muskellunge, rock bass, white sucker, Johnny darter). The acute effects of wastewater on the immune systems of bivalves and fish are also a concern since the immune systems of fish are sensitive to the bacteria present in wastewater, in addition to immunotoxic products. The effects on the immune systems, in addition to the detoxification systems (e.g. MTN, CYP1A1) of fish, could be more significant than the acute effects of untreated wastewater. The risk and the worst scenario would be that the untreated wastewater would cause a loss of immunocompetence at the same time as there are infectious agents present in the environment. In 2001, a viral infection caused by *Aeromonas hydrophile* and *Flavobacterium sp*, following an immunosuppression caused by physiological and environmental factors resulted in high mortality rates in carps (*Cyprinus carpio*) in the St. Lawrence (Monette *et al.* 2006). The other species living in the same areas as the carps were not affected, however, and the selectivity of this effect therefore remains unknown (Monette *et al.* 2006). The immunosuppression of organisms in the receiving waters could render them more susceptible to opportunistic infections.

The City of Montréal discharges untreated wastewater into the St. Lawrence during heavy rains or major snowstorms when the volume of water exceeds the water treatment plant's capacity. There are therefore unplanned discharges of more modest volumes that are released from time to time into the St. Lawrence. Unfortunately, no information is currently available on the consequences of these discharges on aquatic wildlife. This does not confirm the absence of effects, but rather that no one has reported any effects and that the phenomenon has not been studied.

# Risks Associated with an Unplanned Discharge

"What are the level and type of risk presented by the unplanned discharge of untreated wastewater if the work planned by the City of Montréal is not carried out?"

The purpose of the planned discharge by the City of Montréal is to dry out the southeast interceptor of the collection network (see diagram in Appendix 2) in order to carry out work on the wastewater and snow management infrastructure in order to direct both to the J.-R. Marcotte wastewater treatment plant. The various types of work, grouped into three categories and presented previously in Figure 2, therefore include maintenance work and construction work. The risks were evaluated by separating the analysis of the maintenance work from the analysis of the construction work.

## Risks of breakage in the infrastructure without maintenance

The information currently available limits the risk assessment of breakages in the infrastructure or water management problems in the interceptor. However, the condition of the braces as viewed in 2010 using raft-mounted cameras (as described in the documents provided) and the observation of large-size debris that reached the treatment plant allows us to foresee that the condition of the infrastructure has deteriorated over the last five years. In a context of temporary structures (not designed to be long-lasting) and a corrosive environment, such as that of wastewater, this deterioration is expected. As well, the deterioration process of such structures is frequently not linear and accelerates with time, due to the destabilization of the entire structure when a certain level of deterioration is reached. The detachment of wood pieces, metallic grating parts, or metal that makes up the braces may lead to various problems. The detached pieces may, among other things, cause blockages in the valves used to manage wastewater in the interceptor and network. This debris, which is large compared to what is normally found in wastewater, can also accumulate at certain locations in the interceptor and cause the formation of jams, formed by a mixture of brace debris and suspended material found in wastewater. These piles of material create "plugs", altering and restricting the flow of water in the interceptor. This may limit the station's treatment capacity or, in the worst case, cause sewer backflows.

Previous inspections of the infrastructure and various problems that have occurred in recent years have also made it possible to determine that certain pieces of equipment have surpassed their useful life and, in certain cases, are defective. For example, the corrosion of a cast-iron structure is currently causing a control valve to malfunction. Performing this work would allow this defective or problematic equipment to be repaired and for maintenance priorities to be identified for the coming years.

Considering the condition of the infrastructure described in the documents provided and the importance of good water management in the interceptor in order to ensure maximum treatment capacity, limit discharges during periods of rain, and minimize the risks of sewer backflows, maintenance work planned for the southeast interceptor seems to be urgent.

## Risks without construction work

The work associated with the installation of a new snow dump is of a different nature. Not installing this snow dump would limit the effectiveness of snow removal measures and would cause some inconveniences, but would not cause unplanned wastewater discharges. However, it is important to note that this work will be done alongside the removal of braces in order to take advantage of the planned drainage of the interceptor to perform that other work.

## Aggravating factors in the event of breakage

Not performing the previously described work may lead to the need for emergency work. At the very least, this would lead to an equivalent discharge of untreated wastewater into the St. Lawrence in order to perform the necessary work. The potential aggravating factors in such a situation are summarized in Table 1.

*Table 1 – Summary of aggravating factors from an unplanned discharge of equivalent volume*

| | |
|---|---|
| **Public health** | A discharge during a time of year when the water is warmer would cause a greater proliferation of cyanobacteria and pathogens, increasing the risks of contamination for the public and ecosystems.<br><br>A discharge during the summer would lead to a heightened risk of exposure to contaminated water, given the higher presence of people near waterways during the summer. |
| **Wildlife** | The Ministère des Forêts, de la Faune et des Parcs (MFFP) (department of forests, wildlife and parks) has indicated that a discharge during the period from March 1 to March 31 and during spawning would have a potentially significant impact on spawning and the development of young fish. An unplanned discharge could occur during that time of year, when the receiving environment is more sensitive. |
| **Aquatic activities** | A discharge during the season for aquatic activities would cause inconveniences for users (restricted access, odours, etc.) and could cause a complete closure of access to more than 30 km of the St. Lawrence's shoreline during the summer.<br><br>Limited access to the St. Lawrence during the summer months would lead to financial losses for companies that operate in that field. |
| **Snow removal** | With work that requires the closure of 13 other snow chutes, a period of unplanned work during the winter months would cause problems for snow removal and therefore complicate traffic in a part of the City of Montréal. The alternative would be to discharge untreated snow into the St. Lawrence, which would be added to the discharge of untreated wastewater during the work. |

## Conclusions regarding the risks associated with an unplanned discharge

The completed analysis shows the presence of significant risks of breakage or problems that may occur in the wastewater collection infrastructure, which is the first key step in treating the City of Montréal's wastewater, i.e. sending the water to the plant. The deterioration of the infrastructure could also limit the station's treatment capacity, which would lead to greater discharges during periods of rain or unplanned discharges for emergency work. This analysis also identified several aggravating factors inherent to an equivalent discharge of untreated wastewater due to unplanned work, rather than in the context of careful planning. The planning of work offers the possibility of minimizing the potential impact on public health, wildlife, activities, and winter snow removal associated with a discharge of untreated wastewater into the St. Lawrence.

# Environmental risks associated with the best-/worst-case scenario

"In terms of risks to the environment, what would be the best and worst case scenarios for (a) a planned discharge under controlled conditions and (b) an unplanned discharge under unpredictable conditions?"

The environmental risks associated with an unplanned discharge under unpredictable conditions (worst-case scenario) were compared to the risks associated with a planned discharge under controlled conditions (best-case scenario). Five types of risks were identified and evaluated in a relative manner. Table 2 presents the results of that analysis.

*Table 2 – Environmental risks associated with the best-/worst-case scenario*

| Types of risks | Possible causes |
|---|---|
| **Longer discharge period**<br><br>**INDETERMINATE VS. 7 DAYS** | • Delay in the start of work to recruit teams that are specialized in working in confined spaces<br>• Limited availability of the required equipment and replacement parts<br>• Longer duration of work due to a lack of planning<br>• Series of breakages causing additional damage to infrastructure |
| **Higher quantity of discharged water**<br><br>**INDETERMINATE VS. 8 BILLION LITRES** | • The quantity of untreated water discharged into the St. Lawrence is proportional to the stoppage time for carrying out repairs<br>• The loss of treatment capacity due to lack of maintenance increases the quantity of discharged water during periods of rain |
| **Receiving environment more sensitive at certain times of year**<br><br>**MID-OCTOBER TO MID-NOVEMBER VS. INDETERMINATE PERIOD** | • The receiving environment is more sensitive at certain times of year, including the period from January to February, March 1 to 31, and during spawning and the development of young fish.<br>• Pressure on drinking water treatment would be higher in the event of a discharge during summer, which would be conducive to the proliferation of pathogens<br>• The depletion of oxygen in water is more problematic during summer |
| **Risk of backflow**<br>**HIGH DURING A BREAKAGE VS. NEGLIGIBLE** | • An accumulation of debris at the braces can cause bottlenecks, creating jams that could lead to sewer backflows |
| **Limited time to inform and educate the public**<br><br>**NO TIMEFRAME VS. SEVERAL DAYS** | • Performing unplanned work does not offer the opportunity to inform the public and the various parties (drinking water treatment plants, swimmers, fishers, etc.), of the risks and to educate businesses in order to minimize their waste during a discharge. |

### Conclusions regarding relative environmental risks

All of the risks associated with a discharge of untreated wastewater are heightened in the event of an unplanned discharge.

# Possible mitigation measures

"Are there other technically feasible measures the City of Montréal could take to mitigate the effects of the planned discharge or to reduce the likelihood of an unplanned discharge?"

To start, the study and analysis of the information that was provided and made available to the experts by the City of Montréal and the MDDELCC to answer this question were carried out within a short period of 12 days. In addition, the objective of mitigation measures is not necessarily to completely eliminate all effects, but to reduce the effects, even minimally, based on the available means. The benefits and later windfall that the implementation of measures may create must also be considered, not only to protect the receiving environment, but also to acquire knowledge and maintain the public's trust in its institutions. Therefore, any approach must be based on the dynamics of the system by examining each discharge point (24 points along the shores of the Island of Montréal), while looking at the effect of the discharge as a whole. In a context of sustainable development, measures for mitigating the effects of the discharge must account for both the St. Lawrence ecosystem (biological, biochemical, chemical, and physical parameters) and the parameters of man-made systems (socio-economic parameters). For example, mitigation measures must affect pollution parameters and inconveniences. They must also be based on the principles of good governance.

Before addressing the mitigation measures presented by the City, it must be understood that the volume of water is not a real problem, since natural, unpolluted water would not have any effect on the quality of a waterway. Thus, the real problem with a discharge is the matter that it contains. As a result, the volume of 8M $m^3$ may be greater if there is rainfall during the work period, since it has been calculated for the average flow during dry periods. This increase in flow would not change the amount discharged into the St. Lawrence River, but must be taken into account when evaluating potential mitigation measures, since several depend on the volume in question.

## Mitigation measures studied

The evaluation of mitigation measures is based first on the documents submitted and then on the expertise of committee members. Furthermore, the possibility of performing work without draining the southeast interceptor in order to totally avoid the discharge was not studied due to the risk to worker health and safety from such an approach, as well as the lack of documented data regarding the use of such a work technique over a long period of time at such depths in a wastewater interceptor and in conditions that involve toxic fumes.

In no particular order and to avoid duplication, the mitigation measures are presented (**in bold**) along with the City's position on implementing these measures (*in italics*) and the committee's comments and suggestions (in normal font):

1. **Completing all of the work in an integrated manner.**

   *The City presented an action plan for this.*

   During maintenance or other work that requires the draining of an interceptor, it is essential that all work upstream from the closure be performed during the same time period in order to minimize the volume of untreated wastewater to be discharged into the St. Lawrence River or the Rivière des Prairies. In the medium term, the City should evaluate the possibilities of techniques for isolating sensitive segments by planning (construction) for diversions and/or interconnections or meshes.

2. **Build a second southeast interceptor to obtain redundancy.**

   *The City did not retain this measure because this solution cannot be implemented quickly (five years). The City also indicated that it would cost $1 to 2 billion.*

   It must be considered that it would be best for the southeast interceptor to remain functional (bringing wastewater to the treatment station) for a number of years yet. Therefore, it must be maintained just like any infrastructure (houses, overpasses or roadways) and this will require further discharges, unless other strategies are implemented. Similar to point 1, it would be best for the City, like many other cities around the world, to pursue its reflection on installing bypass devices (or infrastructure) at strategic points in the network to reduce discharges.

3. **Work around the clock to reduce the volume of water.**

   *This measure was retained by the City of Montréal.*

   This is an essential mitigation measure. In this regard, monitoring the work is crucial to obtaining the expected results.

4. **Perform the work when the St. Lawrence River is not being used for recreation.**

   *This measure was retained by the City of Montréal.*

   This truly assists in mitigating the effects of the discharge on users of the St. Lawrence River (direct bacteriological contamination, odours, visual aesthetics). The City has stated that it would intensify monitoring and this point is also crucial for meeting the objectives of this mitigation measure. In addition, particular attention should be paid to Aboriginal peoples along the St. Lawrence River, given their closer proximity to and greater use of that environment.

5. **Inform, warn, and maintain dialogue with all municipalities along the St. Lawrence and its estuary regarding the work, but also about which body (or bodies) of water will be affected by the discharge.**

   *The City is committed to sending a notice of discharge to the MDDELCC three (3) weeks before the start of overflow.*

   This measure of sending notices and information should be expanded to include all municipalities downstream of the City of Montréal in order to include the entire area affected by the passing of the plume. Using new information technologies, this measure is not difficult to implement. Once again, particular attention should be paid to Aboriginal peoples along the St. Lawrence River, due to the use of water by these communities (fishing, plant gathering, drinking water).

   In addition to this measure, it is suggested that visual monitoring by boat or aircraft be planned in order to identify areas, if any, where suspended solids have accumulated. In fact, it must be noted that the average quantity of solid matter collected at the City of Montréal's treatment plant (mechanical rakes-grit chambers) in November 2010 was approximately 38 tonnes of residue and approximately 1,800 tonnes of sand for a total flow of approximately 28.7 $m^3/s$. By a rule of three, according to 2010 data, the southeast interceptor

had generated approximately 4 tonnes of residue and 182 tonnes of sand for 8 million cubic metres. Values of these magnitudes are therefore plausible during the studied discharge. Monitoring this and particularly any floating material is relatively simple. For example, small drones that are available on the market can be equipped with a photo or video camera. In addition to actually showing the visual effect of the discharge (genuine or absent) along the St. Lawrence River, this information will help in better understanding the hydraulics and locating dead zones or accumulations of matter.

This measure would also promote quick intervention for cleaning shores. In addition, it would allow municipalities to adapt the monitoring of the water that feeds their drinking water plants and to adapt the plants' operations to ensure the quality of drinking water provided to residents. It should be remembered that objects or undissolved solids always end up settling (sinking to the bottom), decomposing or washing up on shore (cf. material found in British Columbia that came from the 2011 tsunami in Japan). This measure is complementary to the monitoring measures described later in this document.

6. **Intensifying the monitoring program for industrial establishments targeted by an increase in inspections, sampling, and analyses.**

   *The City will intensify its monitoring, which can be considered as a preventative mitigation measure.*

   The effect of this measure is difficult to calculate. In the event of an incident or problem at a business, the City will only be able to note the discharge in the sewers. In the event of a major discharge of a pollutant (or toxic substance), the City should plan actions such as those used for emergency measures. These actions could be developed through dialogue with industries with the goal of raising their awareness. This dialogue could even lead to preventative measures within the industrial process, since more and more industries are sensitive to their environmental image.

   Although hospitals have not been targeted by the City of Montréal and are not considered to be industries, they nevertheless represent a high risk potential for toxic discharges (acute and chronic) into sewers, due to thenature of their activities (unofficial products, medications, detergents, etc.). Although the City of Montréal provided results showing that wastewater entering the treatment station (influent) and wastewater from the Southeast interceptor did not cause acute toxicity in trout and daphnia, these results may be different for some of the discharge points. For example, the construction and opening of the McGill University Health Centre modified the distribution of loads towards another point of discharge. Furthermore, the results do not include chronic toxicity, which is an increasing concern around the world, even though there is very little regulation of that type of toxicity.

7. **Educating residents to not discard items or objects into toilets that could pollute the St. Lawrence during a discharge.**

   *This measure is planned by the City of Montréal.*

   This measure is important to the social acceptability of the discharge, although its contribution remains unclear and its actual effect is difficult to quantify. However, it shows that the City has thought about involving its residents.

   Nevertheless, the message must be clear and convincing. For example, a simple prohibitory sign containing an image or icon can cause confusion. A condom, a cigarette butt or a bunch of pills in a prohibitory sign, as proposed in the documents from the City, may be understood as prohibiting the use of protection during sexual relations, smoking or taking medication. This detail may appear anecdotal, but due to the broad media coverage of the discharge, image is very important to an awareness campaign. It would be preferable to depict these items above a toilet.

8. **Cleaning the shores, if necessary, in the discharge area.**

   *The City is committed to doing this.*

However, the concept of an affected area is vague. It could simply be along the shores of the Island of Montréal or along the St. Lawrence River and its estuary. It is obvious that all waste from Montréal that washes up on a shore should be removed. However, to be fair and avoid abuse, the situation before the discharge should be known or the plume should be monitored and clean-up should occur as needed.

Listening to cities and communities downstream from the Island of Montréal, the City should pay particular attention to sensitive areas like the banks of aquatic plants in the Sorel islands, which present a major risk for capturing particulates and debris discharged by Montréal. Cleaning in such areas must be planned with local stakeholders in order to be able to act together and quickly, if needed.

9. **Installing an inflatable valve (inflatable ball) to have retention in the collectors or the interceptor**

*The City did not retain this solution due to unacceptable risks for the workers.*

In effect, a ball does not guarantee the water tightness of the system. The risks for workers are therefore real unless several balls are placed in series to reduce the risk. However, the obstruction of the pipes during the work would push the wastewater upstream. The volume available would probably not be enough to contain all the water, which would then overflow into the streets, industries, or residents' homes. The release of toxic gas in the pipes could also remain problematic.

10. **Installing temporary pipes to divert the wastewater from the southeast interceptor (south shore of the island) to the north interceptor**

*The city did not retain this measure due to the distance separating the two slopes (4 to 6 km) and the fact that this overload in the north interceptor could result in overflows into the Rivière des Prairies, which flows at a slower pace than the St. Lawrence. The risk of impact would therefore be greater.*

Here again, this measure must be considered as a potential alternative for certain sectors of the network to avoid wastewater discharges in the future due to maintenance on the interceptors. Moreover, the City has integrated this possibility into its future master plan.

11. **Installing mobile treatment units**

*The city did not retain this mitigation solution due to the number of units (1,500 units at 750 $m^3/d$), physical layout unfeasible, and pumps of non-standard capacity.*

However, this summary analysis was conducted with the total flow discharged and, it would seem, to achieve the discharge objectives for the station. As a mitigation measure, a unit such as a simple dissolved air float the size of a 40-ft transport container could eliminate a significant percentage of suspended solids, oils and greases. With a flow of 80 $m^3/h$, or approximately 0.02 $m^3/s$, such a unit could treat the discharges from one or more of the 14 diversion structures of the 27 total, or one or more discharge points. A more comprehensive analysis of each technique available on the market could have been conducted for the discharge points considered separately rather than overall.

According to the same principle, it would have also been possible to act at the source of the discharge, i.e. where the discharge was released, with partial treatments targeting certain contaminants of concern (such as persistent organic compounds or endocrine disruptors) at hospitals. For the discharge case evaluated, treatment at the source would have the benefit of having lower flows and therefore smaller facilities. However, the process likely to be used is based primarily on physical treatments, and perhaps even chemical treatments. In effect, the kinetics of the biological processes are probably too slow. The retention times required would be too long, thus requiring larger infrastructure.

This mitigation measure through the implementation of treatment processes is the most likely to ensure a reduction of the mass of pollutants. However, it would require more in-depth studies in terms of technical and economic feasibility, but also in terms of energy and atmospheric emissions.

**12. Installing recovery screens**

*The City did not retain this solution due to problems with clogging (risk of backups into the residential network).*

These risks are real, but can be eliminated by regular cleaning. Little information is currently available to assess the implementation of this measure. This measure could be implemented in strategic areas that are easy to access for cleaning.

**13. Using tanker trucks to transport wastewater to the station**

*The city did not retain this solution because more than 45,000 trucks/day would be needed to transport the wastewater from the south interceptor to the treatment plant.*

In addition to the inconvenience of the presence of trucks on the road (risk of accidents and increased traffic jams) and nuisances for residents (noise, odours, stress), these trucks would burn fossil fuel, transforming the pollution released into the St. Lawrence into air pollution, thus contributing to an increase in the risk of climate change.

**14. Using tanker ships to collect all wastewater until the work is completed**

*The City did not retain this solution due to the number of ships that would be needed to store all the wastewater (200 tanker ships 220 m long by 23 m wide, with a capacity of 36,000 tonnes).*[1] *The City also presents the case of a ship docked at the "Parc Bellerive" discharge point (anticipated discharge flow of approximately 2.9 m³/s) to give an idea of the filling time (3.5 hours) and confirm the pace at which ships would be changed. That pace is mandatory according to the City because [Translation] "there is no other reasonable technical solution for disposing of this wastewater as it accumulates on the ship".*

That statement is somewhat simplistic. A system would simply need to be created to get the wastewater out (overflow or spillway). The principle of an inverted siphon could be adapted to control water levels in the ship's tank. The water could be taken at mid-height in the tank without altering the structure of the ship subsequent use of the ship (temporary solution). It must be noted that the retention time of 3.5 hours is relatively long for primary settling tanks or flotation. Without necessarily treating all discharge points, it would have been a good idea to retain this solution for larger flows and to examine its application in more detail, considering logistical and economical aspects.

The benefit of this solution also rests in the fact that the ships have electrical power supply systems. As well, the use of this measure in particular is the only one that facilitates sampling for monitoring purposes and that also allows the amount of solid waste discharged from a discharge point (total mass) to be quantified and qualified, even summarily. It also makes it possible to add other principles to increase the removal of physical parameters (introduction of air to improve flotation) or bacteriological parameters (using ozone).

**15. Installing nets or floating barriers**

*The City of Montréal rejected this measure for the following reasons: [Translation] "the outlets of most overflow points are at most 30 to 50 metres from the shore and several metres deep"*[1] *(suggesting less than 10 metres), "the use of nets would further hinder aquatic life, as fish could become trapped in them"*[1] *and "boom-style barriers (without nets) to cover a distance of 30 km would be hard to find on the market, as that type of floating barrier usually covers distances from a few dozen metres to a few hundred metres at most".*

For floating barriers, the idea should not be to surround the southern part of the Island of Montréal, but instead to set up the barriers at strategic locations where floating debris or oils and greases would surface, to push them back to the shore. In that perspective, one or two 100-metre barriers could suffice. Regarding

[1] Text taken from the two-page memo from the City of Montréal entitled "Sommaire de l'analyse des solutions alternatives évoquées : travaux sur l'intercepteur Sud-Est" (summary of the analysis of the alternative solutions cited: work on the southeast interceptor), dated October 8, 2015

nets, it is true that they could hinder fish, which could become trapped. Tubular nets (open at both ends) would need to be considered, which would "control" and come up to the surface. Due to currents, an evaluation of this measure would require more work and time. The explanation of the reason cited by the City mentions that most outlets are far from the shore. As we do not have the plan for each outlet, this suggests that some outlets are not. If these are at the surface, steel nets could be spread on the surface to collect solids.

However, this problem shows that most outlets at discharge points are far from the shore and are at depths. This technique was used in most western countries to improve the dispersion and dilution of discharges and to take away sanitary risks and inconveniences for shoreline residents. It also helps avoid and mask the foaming effect of wastewater due to surfactants (such as detergents). With a view to continual improvement and in a spirit of sustainable development, the City should address this point in its next master plan in order to find solutions that would allow for the gradual and easier implementation of wastewater treatment strategies.

## Measures added by the City

At the end of one of its presentation documents, the City of Montréal noted its desire to implement solutions to reduce its environmental impact on the river.

**16. Automated interceptor management**

*This type of management actually reduces discharges in the event of rain by retaining as much water as possible in the network and the interceptors.*

It must be noted, however, that this automation is related to sensors and back-flow valves that require maintenance (one of the types of work associated with the discharge being studied).

**17. Elimination of inverted connections**

*The elimination of connections would avoid the inversion of the connection between the sanitary sewer and the storm sewer, resulting in a runoff of sanitary wastewater in the storm sewer system or in a waterway.*

This measure is only valid for sections of the separate system (one network for rainwater and one network for sanitary wastewater). The impact is therefore minor on a discharge caused by the closure of the southeast interceptor, as it is a combined network.

**18. Construction of retention basins**

*The City actually built retention basins to reduce the maximum flows during periods of rain (part of the flow in excess of the maximum flow that the treatment plant can treat) by storing it until the treatment plan can treat that volume.*

This infrastructure would help reduce an overflow, but it would require the construction of 1,500 wastewater retention basins similar to the Marc-Aurèle-Fortin retention basin (at the north interceptor, with a capacity of approximately 5,300 $m^3$, on which work began in 2015 and is scheduled to end in 2016) or 228 times the Domaine Chartier retention basin (volume capacity of 35,000 $m^3$) to contain the volume of the discharge caused by closing the southeast interceptor. Depending on the number and capacity of basins implemented, they would allow for a fairly significant reduction in future discharges.

**19. Installation an ozonation system to treat wastewater at the treatment plant**

*The City aims to launch the ozonation system in 2018.*

This infrastructure will in no way change the quality of the wastewater discharged as a result of closing an interceptor. However, it shows the City's desire to improve the performance of the treatment plant. Ozonation will improve the quality of the wastewater discharged into the St. Lawrence River by reducing

microbiological parameters (bacteria, viruses), chemical parameters (suspended solids, chemical oxygen demand, endocrine disruptors, and certain pharmaceuticals that are persistent in the environment) and aesthetical parameters (colour, odour). However, it is highly likely that future discharges of undiluted wastewater caused by maintenance on the southeast interceptor (or even overflow from heavy rain) will be much more visible over the coming years.

**20. Development of a drainage master plan for the Island of Montréal**

Without any concrete information regarding this master plan, it is difficult to address the benefits that it could have on a discharge once the master plan is applied. However, if the plan includes the desire to make urban lands more permeable in order to reduce rainwater in the interceptors, attention must be given to the quality of the rainwater. Rainwater or runoff water on urban land can also contain contaminants such as used snow. Over the long term, the pollution contained in such water could contaminate the soil and the water table. Additional studies of the long-term impacts of permeabilization of urban lands are desirable in the context of sustainable development.

## Conclusions regarding mitigation measures

To summarize, the City presented fifteen possible measures (no. 1 to No. 15) that could reduce the effects of releasing 8 million cubic metres of untreated wastewater directly into the river. The City also presented five other measures (No. 16 to No. 20) for reducing overflows, but that would have little effect on the type of discharge being studied.

The City retained 7 of the 15 measures (No. 1 and Nos. 3 to 8) that could be enhanced for better monitoring. Of those 7 measures, the actual discharge mitigation effects of three are difficult to quantify and verify.

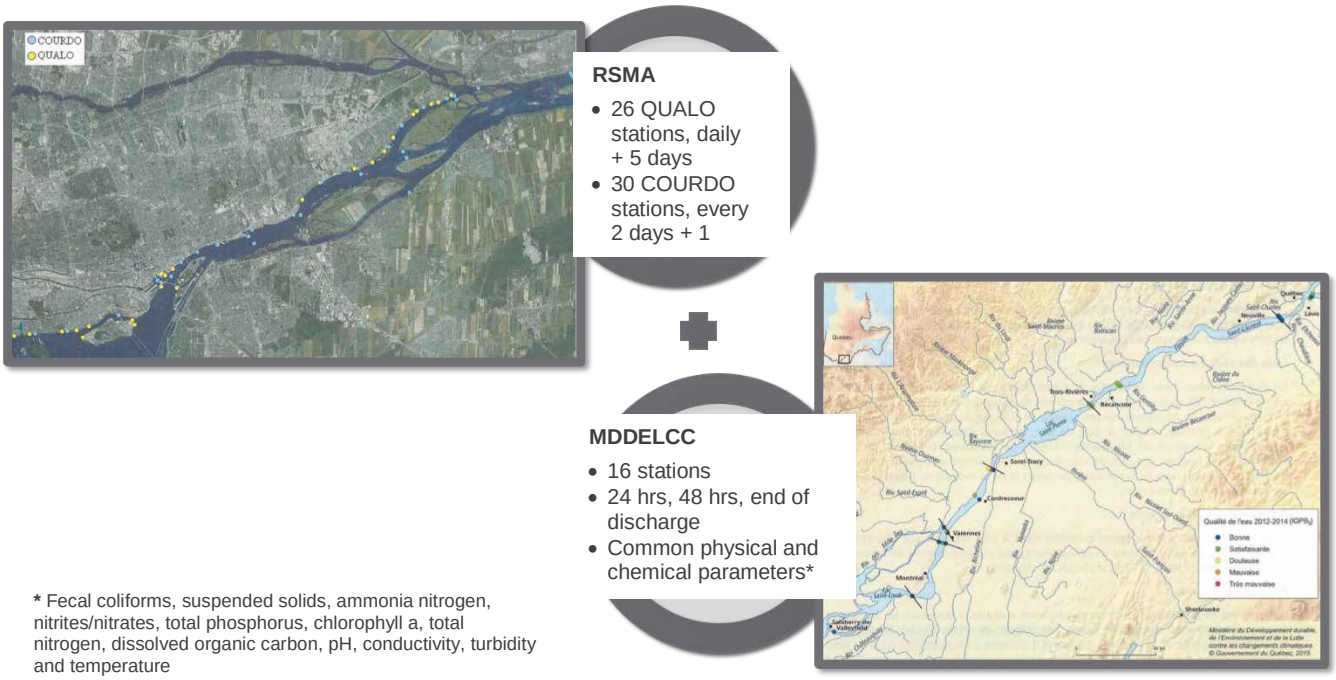
Of the 8 measures that were not retained, 5 would actually reduce pollution or inconveniences from the discharge. They would have merited closer study. For the discharge period currently being considered (November 2015), however, it is not realistic to implement them all. However, with the support of both levels of government, the City should make every effort to implement three (3) additional mitigation measures. The first measure (No. 14) consists of using a tanker ship with an inverted siphon. The use of that measure for one of the main discharge points should be reconsidered. The second (combination of measures No. 5 and No. 8) consists of a better monitoring of the plume discharged beyond the shores of the Island of Montréal, associated with an emergency plan for cleaning up the matters discharged, particularly near the Sorel islands. The third measure (No. 11) is to use a mobile treatment unit by targeting a potentially toxic discharge into the sewer, such as the McGill University Health Centre, another hospital, or even an industry.

All suggestions and improvements presented should be seriously considered for longer-term improvements to mitigation measures for future discharges of wastewater during maintenance on interceptors. Moreover, the proposed measures could be tested on overflow (wastewater diluted by rain when the maximum flow at the treatment plant is reached). The information and data acquired would help in documenting the effectiveness of these measures. This information could be distributed around the world and demonstrate leadership as an environmentally responsible city.

# Water Quality Monitoring

"Are there any other criteria that should be included in the water quality monitoring planned by the City of Montréal or any other changes to such monitoring that would increase its effectiveness and that are financially feasible?"

In cooperation with the Réseau de suivi du milieu aquatique (RSMA) (aquatic environment monitoring network) and the MDDELCC, the City of Montréal has created a special water quality monitoring program for the untreated wastewater discharge period. Figure 2 provides a summary of that proposed monitoring program.




***** Fecal coliforms, suspended solids, ammonia nitrogen, nitrites/nitrates, total phosphorus, chlorophyll a, total nitrogen, dissolved organic carbon, pH, conductivity, turbidity and temperature

*Figure 3 – Special water quality monitoring program proposed by the City of Montréal*

## Plant monitoring

Concentrations of heavy metals in submerged plants have fallen by 80 to 600% since the treatment plant began operation (Hudon 1998). In the opinion of Dr. Campagna of UQTR, expressed in a GRIL press release, the largest organic waste would be captured in the plant banks at Sorel. If that is the case, the contamination of those sediments should be determined, as the risk of accumulation of harmful products in submerged plants at those sites could represent a contamination vector for herbivore fish. A high level of contamination could indicate the need for corrective measures. It is also important to consider that some plants are used by aboriginal peoples for their medicinal value.

## Fish monitoring

More comprehensive environmental monitoring would obviously be desirable. An analysis of the physiological responses of fish and bivalves using exposure and health biomarkers in the discharge areas and downstream would have made it possible to evaluate the toxicity of the effluent on wildlife in the receiving water. In the event of

significant toxicity, this would not prevent effects on wildlife, but in the event of less toxicity, it would help foresee the consequences over the short and medium terms. Moreover, such monitoring would provide essential information for the eventual evaluation of new needs to discharge untreated wastewater into the river.

Given that fish monitoring can be difficult, an alternative indirect risk assessment approach should be considered. That approach would help assess whether there would be an accumulation of toxic substances in higher risk areas of the St. Lawrence following the discharge. To do so, it is recommended that it be demonstrated whether the toxicity of the water and sediments downstream of the discharge particularly in fish spawning areas, increased following the discharge. Toxicity should be monitored using rapid, but well-characterized, tests. In addition to the microbiological tests announced by the MDDELCC, Microtox® toxicity testing should be conducted on sediments at the same site, including fish spawning areas. As well, the toxicity of the water should also be determined using either the Microtox® or other tests, such as LuminoTox® or the Daphnia test. Finally, as several studies have shown that effluent (treated wastewater) is genotoxic, genotoxicity tests based on the Ames test should also be conducted. These analyses should be conducted before, during and after the discharge, on a monthly basis until winter, and the following year during the spawning period. It would also be important to determine whether the sediments in the fish spawning areas show toxicity the following spring. These analyses would give an indication of the contribution of toxicity from the discharge of untreated wastewater and would help establish an initial information base for the evaluation of future discharges.

### Drinking water monitoring

Analyses of currents conducted in the past suggest that water discharged into the St. Lawrence River should follow the brown waters of the St. Lawrence rather than being mixed and reaching the shorelines. In this context, the risks of impact on drinking water treatment plants is very limited, even for the Berthierville and Lavaltrie plants. The City of Montréal states that it discussed the project with officials at those plants and that they are aware of the City of Montréal's plans. Despite the limited risks, however, it is essential, during the discharge period and the following week, to ensure that those plants are particularly vigilant in order to limit the risks associated with an inferior quality of their water source.

### Conclusions regarding water quality monitoring

Given the importance of making up for the lack of knowledge regarding the effects of a discharge of untreated wastewater on the St. Lawrence, it is essential that the monitoring plan be improved. First, the monitoring plan proposed by the City must be maintained beyond the discharge period and until indicators return to their normal values, if they are affected by the discharge. To complement this monitoring by the RSMA and the MDDELCC, characterization of the toxicity of water and sediments in critical areas should be conducted. Finally, careful monitoring must be conducted at the drinking water treatment plants, despite the low risk of impact.

## General Comments

The lack of information on the effects of discharging untreated wastewater into the St. Lawrence River must be addressed in order to avoid continual questions from the public and the scientific community regarding the risks that such discharges may have on aquatic plants and wildlife. Since the current status of the City of Montréal's sewer system shows major signs of ageing, it is obvious that other repairs will need to be carried out over the coming

years and that those may possible result in other discharges into the St. Lawrence. It is therefore essential, in the context of this discharge, if it takes place, that any consequences be characterized in order to provide a point of reference on which the City of Montréal and government agencies can base future requests to discharge untreated wastewater into the St. Lawrence.

# References


1. Andersen,H., H. Siegrist, B. Halling-Sorensen, and T. A. Ternes. Fate of estrogens in a municipal sewage treatment plant. Environ.Sci.Technol. **37**: 4021-4026. 2003.

2. Bernatchez, L., and M. Giroux. Les poissons d'eau douce du Québec et leur répartition dans l'est du Canada. Édition Broquet Inc., Saint Constant, QC. 348p. 2012.

3. Blaise,C., S. Trottier, F. Gagne, C. Lallement, and P. D. Hansen. Immunocompetence of bivalve hemocytes as evaluated by a miniaturized phagocytosis assay. Environ.Toxicol. **17**: 160-169. 2002.

4. Gagne,F., C. Andre, P. Cejka, R. Hausler, and M. Fournier. Alterations in DNA metabolism in Elliptio complanata mussels after exposure to municipal effluents. Comp Biochem.Physiol C.Toxicol.Pharmacol. **154**: 100-107. 2011.

5. Gagné, F., B. Bouchard, C. André, E. Farcy, and M. Fournier. Evidence of feminization in wild Elliptio complanata mussels in the receiving waters downstream of a municipal effluent outfall. Comp Biochem Physiol **153C**, 99-106. 2010.

6. Gagne, F., S. Trottier, C. Blaise, J. Sproull, and B. Ernst. Genotoxicity of sediment extracts obtained in the vicinity of a creosote-treated wharf to rainbow trout hepatocytes. Toxicol.Lett. **78**: 175-182. 1995.

7. Garcia, G. A., A. E. McIntyre, R. Perry, and J. N. Lester. Behaviour of persistent organochlorine micropollutants during primary sedimentation of waste water. Sci.Total Environ. **39**: 27-47. 1984.

8. Houde, M., D. Berryman, Y. de Lafontaine, and J. Verreault. Novel brominated flame retardants and dechloranes in three fish species from the St. Lawrence River, Canada. Sci.Total Environ. **479-480**: 48-56 2014.

9. Houde, M., M. Douville, S. P. Despatie, A. O. De Silva, and C. Spencer. Induction of gene responses in St. Lawrence River northern pike (Esox lucius) environmentally exposed to perfluorinated compounds. Chemosphere **92**: 1195-1200. 2013.

10. Ion, J., and Y. de Lafontaine. Spatial variation of contaminant levels in six species of fish from the St.Lawrence River. Environment Canada – Quebec Region, Environmental Conservation, St. Lawrence Centre. Scientific and Technical Report ST-165E. 74 p. 1998.

11. Ion, J., Y. de Lafontaine, P. Dumont, and L. Lapierre. Contaminant levels in the St.Lawrence River yellow perch (*Perca flavescens*): spatial variation with implications for monitoring. Can. J. Fish. Aquat. Sci. **54** : 2930-2946. 1997.

12. Johnson, A.C. and J. P. Sumpter. Removal of endocrine-disrupting chemicals in activated sludge treatment works. Environ.Sci.Technol. **35**: 4697-4703. 2001.

13. Laliberté, D. Teneurs en polybromodiphényléthers (PBDE) dans les poissons du fleuve Saint-Laurent et des lacs et rivières du Québec (2002-2008), Québec, ministère du Développement durable, de l'Environnement et des Parcs, Direction du suivi de l'état de l'environnement, ISBN 978-2-550-60987-2 , 48 p. 2011.

14. Laliberté, D., Évolution des teneurs en mercure et en BPC de quatre espèces de poissons du Saint-Laurent, 1976-1997, Québec, ministère de l'Environnement, Direction du suivi de l'état de l'environnement, envirodoq no EN/2003/0287, 85 p. 2003.

15. Marcogliese, D. J., C. Blaise, D. Cyr, Y. de Lafontaine, M. Fournier, F. Gagne, C. Gagnon, and C. Hudon. Effects of a major municipal effluent on the St. Lawrence River: A case study. Ambio. **44**: 257-274. 2015a.

16. Monette, S., A. D. Dallaire, M. Mingelbier, D. Groman, C. Uhland, J. P. Richard, G. Paillard, L. M. Johannson, D. P. Chivers, H. W. Ferguson, F. A. Leighton, and E. Simko.. Massive mortality of common carp (Cyprinus carpio carpio) in the St. Lawrence River in 2001: diagnostic investigation and experimental induction of lymphocytic encephalitis. Vet.Pathol. **43**: 302-310. 2006a.

17. Pham, T., S. Proulx, C. Brochu, and S. Moore. Composition of PCBs and PAHs in the Montreal urban community wastewater and in the surface water of the St. Lawrence River (Canada). Water, Air, and Soil **111**: 251-270. 1999.

18. Salo, H. M., N. Hebert, C. Dautremepuits, P. Cejka, D. G. Cyr, and M. Fournier. Effects of Montreal municipal sewage effluents on immune responses of juvenile female rainbow trout (Oncorhynchus mykiss). Aquat.Toxicol. **84**: 406-414. 2007.

19. Schultz, I. R., A. Skillman, J. M. Nicolas, D. G. Cyr, and J. J. Nagler. Short-term exposure to 17-alpha-ethylestradiol decreases the fertility of sexually maturing male rainbow trout (*Oncorhynchus mykiss*). Environ Toxicol Chem **22**: 1272-1280. 2003.

20. Ternes, T. A., M. Bonerz, N. Herrmann, B. Teiser, and H. R. Andersen. Irrigation of treated wastewater in Braunschweig, Germany: an option to remove pharmaceuticals and musk fragrances. Chemosphere **66**: 894-904. 2007.

21. White, P. A., J. B. Rasmussen, and C. Blaise. A semi-automated, microplate version of the SOS Chromotest for the analysis of complex environmental extracts. Mutat.Res. **360**: 51-74. 1996.

# Appendix

## Appendix 1 – List of documents provided for scientific and technical review

**Documents received from the City of Montreal and MDDELCC**

1. Cahier des clauses techniques spéciales. Modifications de la structure de chute et d'accès Riverside et enlèvement des cintrages existant dans l'intercepteur sud (Book of special technical clauses. Modifications to the Riverside dump and access structure and removal of existing braces in the south interceptor). Contract 5062-EC-4360-14. City of Montréal.

*Specific description of the work entailed and the coordination of the different phases of the project. Description of the results obtained from the previous inspections to the south interceptor, including recommendations based on a risk analysis regarding undertaking the work to the support structures due to the modification of the Riverside access into a snow chute.*

2. Group for Interuniversity Research in Limnology. Press release for immediate release. October 8, 2015.

   *Technical information on the impacts of the proposed discharge to the St Lawrence River*

3. Station de traitement des eaux usées de l'ile aux-Vaches - Révision des taux de dilution de l'effluent de l'ile aux Vaches dans le fleuve Saint-Laurent par simulation numérique (Île-aux-Vaches wastewater treatment plant – Revision of effluent dilution rates at Île aux Vaches in the St. Lawrence River by digital simulation). Réseau de recherche en écotoxicologie du Saint-Laurent in cooperation with the City of Montréal. March 2005.

   *Data on plume dispersion and dilution in the St Lawrence River through modelling.*

4. Polytechnique Montréal – Expert position of Polytechnique Montréal regarding the planned discharges of wastewater from the southeast interceptor in the City of Montréal.

   *Technical information on necessity of work to the sewer system in Montreal and impacts to the system if they are not undertaken. Analysis of impacts to drinking water intakes for municipalities downstream of the discharge.*

5. Exchange of emails between the MFFP and the MDDELCC – November 28, 2014.

   *Correspondence about timing of the work regarding environmental impacts*

6. Exchange of emails between stakeholders at the MDDELCC – December 16, 2014.

   *Correspondence about timing of the work regarding environmental impacts*

7. Request for a technical opinion regarding the temporary interruption of the east section of the southeast interceptor in Montréal. Memo from the MDDELCC. October 1, 2015.

   *Correspondence about timing of the work regarding environmental impacts*

8. Request for a technical opinion regarding the temporary interruption of the east section of the southeast interceptor in Montréal. Memo from the MDDELCC. December 9, 2014.

   *Correspondence about timing of the work regarding environmental impacts*

9. Note technique (Version provisoire - Document de travail) - Caractérisation de la qualité de l'eau, projet de la plage de l'est à Pointe-aux-Trembles (Technical memo (draft version – working document) – Characterization of water quality, east beach project at Point-aux-Trembles). City of Montréal – water service. Wastewater treatment branch. October 2, 2015.

   *Description of water quality related to wastewater effluent discharges in the St Lawrence River,* particularly at the Pointe-aux-Trembles beach in summer (east end of the Island).

10. La qualité des eaux autours de l'ile de Montréal. 1973-2000. Portes ouvertes aux usagés (Water quality around the Island of Montréal. 1973-2000. Open door for uses). Montréal Urban Community and Environnement Québec.

    *Description of the water quality around the Island of Montreal during 1973 to 2000 from monitoring data.*

11. Programme COURDO/QUALO-special2015. Échantillonnage des cours d'eau lors du déversement d'eaux usées non traitées au fleuve Saint-Laurent (Special 2015 COURDO/QUALO program. Sampling from waterways

during the discharge of untreated wastewater in the St. Lawrence River). Réseau de suivi du milieu aquatique (RSMA), City of Montréal. October 2015 (October 9, 2015 version).

*Description of the water quality monitoring program for the 2015 discharge of untreated* wastewater to the St Lawrence River

12. Bilan Environnemental 2013. Portrait de la qualité des plans d'eaux à Montréal (2013 Environmental report. Portrait of the quality of waterways in Montréal). City of Montréal environment service. 2nd Quarter 2014.

*Report on water quality monitoring programs for water bodies in and around Montreal for 2013*

13. Bilan Environnemental 2014. Portrait de la qualité des plans d'eaux à Montréal (2014 Environmental report. Portrait of the quality of waterways in Montréal). City of Montréal environment service. 2nd Quarter 2015.

*Report on water quality monitoring programs for water bodies in and around Montreal for 2013*

14. Travaux prévus à l'intercepteur sud-est de réseau d'égout de Montréal en 2015. Considérations environnementales (Planned work on the southeast interceptor of the Montréal sewer system in 2015. Environmental considerations). October 8, 2015.

*Description of project and environmental impacts, mitigation measures, alternative options considered.*

15. Sommaire de l'analyse des solutions alternatives évoquées (Summary of the analysis of the alternative solutions cited). City of Montréal. October 8, 2015.

*Description of alternative options considered by the City of Montreal*

16. Guide de gestion des eaux pluviales. Chapitre 2 : Impacts et Justifications. (Rainwater management guide. Chapter 2: impacts and justification). Ministère du développement durable, de l'Environnement, de la Faune et des Parcs and Ministère des Affaires municipales, des Régions et de l''Occupation du territoire

*Generic description of rain water management in urban settings*

17. Travaux sur l'intercepteur sud-est (Work on the southeast interceptor). Technical presentation. City of Montréal. October 8, 2015. PowerPoint document.

*Description of the project, alternatives, impacts to drinking water, mitigation measures for social and environmental impacts, and impacts of not going ahead with the work.*

18. Avis de débordement au Fleuve et de modulation de la capacité de traitement de la station d'épuration des eaux usées de la Ville de Montréal (Notice of overflow into the river and modulation of the treatment capacity of the City of Montréal's wastewater treatment plant). Email sent 2015-09-30 from the City of Montreal to Environment Canada, with attachments of past communications from the City of Montreal to MDDELCC and Environment Canada.

*Summary of the project. With attached documents: provincial authorization certificate, technical notes on the project from the City to MDDELCC.*

19. Suivi de la qualité de l'eau (Water quality monitoring). MDDELCC. 2015.

*Description of the provincial water quality monitoring program for the discharge and map of the sampling stations.*

20. Résumé des résultats de bioessais de toxicité létale réalisés sur l'effluent de la station d'épuration des eaux usées (Summary of the results of bioassays of lethal toxicity of effluent from the wastewater treatment plant). Jean-R. Marcotte.

*Summary of acute lethality bioassays on treated wastewater effluent for years 2014 and 2015 and laboratory reports*

21. Letter from City of Montreal to Environment Canada dated October 16, 2015 and attached technical presentation dated October 16, 2015 (PowerPoint).

**Other documents**

22. Simulation des panaches de rejets Ville de Montréal (City of Montréal simulation of discharge plumes) October 8, 2015. Hydrology and Ecohydraulics Section. National Hydrological Services. Environment Canada. October 8, 2015.

    *PowerPoint document, presented at meeting with City of Montreal on October 8. Description of the plume dispersion.*

23. List of planned discharge locations and maps provided by the City of Montreal (email). October 2, 2015.

24. Effects of a Major Municipal Effluent on the St. Lawrence River: A Case Study, AMBIO, DOI 10.1007 /s13280-014-0577-9. Royal Swedish Academy of Sciences. Authors: David J. Marcogliese, Christian Blaise, Daniel Cyr, Yves de Lafontaine, Michel Fournier, François Gagne, Christian Gagnon, Christiane Hudon. Published online November 23, 2014.

25. Données de qualité des eaux usées de la station d'épuration des eaux usées (Data regarding the quality of wastewater from the wastewater treatment plant). Jean-R. Marcotte, City of Montréal. Quality of south effluent and quality of effluent in 2014.

**Appendix 2 – Diagram of the wastewater collection network**