

**Report of the Auditor General
of the Ville de Montréal**
to the City Council and to the
Urban Agglomeration Council

For the Year Ended December 31, 2013

5.9

Water Line Breaks

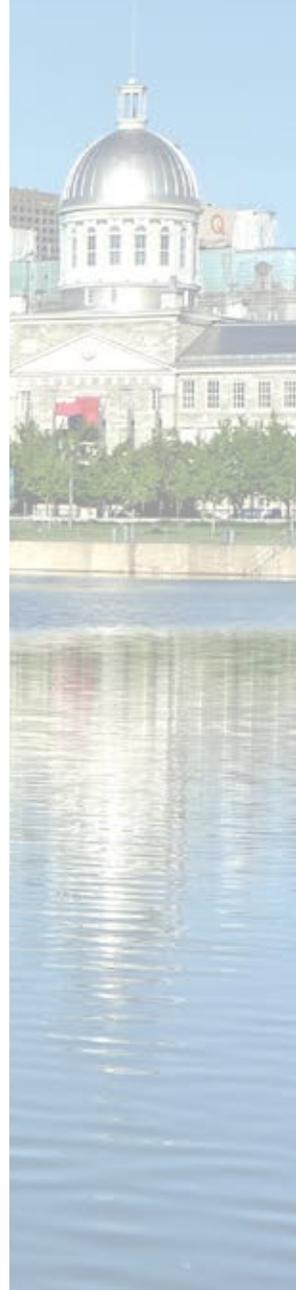


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List of Acronyms

BIS	borough information system	SGIS	spatial geographic information system
DEP	Direction de l'eau potable	SITE	Service des infrastructures, du transport et de l'environnement
DGSRE	Direction de la gestion stratégique des réseaux d'eau	STI	Service des technologies de l'information
RP	response plan		

5.9. Water Line Breaks

1. Introduction

The water supply system for which the Ville de Montréal (the city) is responsible consists of water lines, service lines, valves and fire hydrants.

In terms of water lines, the system managed by the city comprises a total of 4,312 km of water mains (primary system) and lateral mains (secondary system).¹ Water mains (740 km) are located on the Island of Montréal and carry water from filtration plants to various parts of the city and related municipalities. They are distinctly larger in diameter, varying from 400 mm to 2,700 mm. The city also manages the lateral mains located within its boundaries (3,572 km). They are connected to the water mains and their diameter generally varies between 100 mm and 400 mm.

Service lines are another kind of water line that supplies drinking water to private properties, business establishments and industrial facilities. Each line consists of two sections: one that belongs to the city and one that belongs to the corresponding property owner. The water supply system managed by the city comprises some 260,000 service lines.

Valves are mechanisms installed on water lines to control or stop the flow of water in certain parts of the distribution system to facilitate inspection, cleaning, repair, rehabilitation or replacement work, simultaneously cutting off access to drinking water for part of the population. The secondary water system features a total of 32,348 valves, while the primary water system has 1,900.

Fire hydrants are designed primarily to supply water to fight fires, although they are also used by public works directorates in their operations. Some 22,600 fire hydrants fall within the city's jurisdiction.

For the water systems under the city's purview, the legislative framework currently in force, following the merger and reconstitution of several municipalities on the Island of Montréal, dictates that the urban agglomeration council is the body responsible for the primary system. Water main maintenance has been delegated to the city and the related municipalities. And the city in turn has sub-delegated water main maintenance to the boroughs. The secondary water system is the responsibility of city council, except for the downtown core, which is under

¹ The figures in Section 1 of our audit report were taken from the Service de l'eau website on March 5, 2014.

the urban agglomeration council's jurisdiction. The maintenance of these water lines has also been delegated, or sub-delegated, to the boroughs by the city council.

More specifically, the responsibility for managing all water system assets falls to two operational directorates of the Service de l'eau. The Direction de l'eau potable (DEP) oversees drinking water production and distribution and the management of primary water infrastructure. The Direction de la gestion stratégique des réseaux d'eau (DGSRE) is tasked with working with the boroughs to implement a management scheme for secondary water assets, especially as it pertains to infrastructure maintenance and renewal.

The minimal budgets earmarked for maintenance work in past years have contributed to the poor condition of the water systems. This has resulted in numerous breaks year after year in primary and secondary water lines.

The Service de l'eau defines a water line break as a burst pipe. When this occurs, water may push up to the surface and gush out of the ground. Breaks often cause an interruption in water supply, which is a major inconvenience for residents and the general public. Such problems also require urgent and very costly repairs and generate negative media coverage, which over time undermines the city's credibility. According to the most recent figures compiled by the Service de l'eau,² the average number of secondary water line breaks repaired per year between 2006 and 2012 was 800. Figures for the primary system during this same period have not been compiled. However, a total of 57 burst water mains were repaired in 2012.

We should point out that these figures do not take into account as-yet undetected underground leaks, which can be thought of as non-visible water line breaks that have not yet caused any outward damage. These leaks can persist for months or even years. Not only do they waste drinking water, they represent a risk in terms of subsequent damage that will require emergency repairs.

One of the ways to reduce the number of breaks is by rehabilitating or replacing decaying water lines. A response plan (RP) was developed by the city in 2005 for the purpose of creating a georeferenced inventory of water and sewer lines throughout the Island of Montréal and collecting information to determine the condition of the corresponding infrastructure. The RP was also supposed to identify priority water lines for rehabilitation or replacement in the coming years. Between December 2009 and May 2010, RPs were completed for the primary water system and the secondary water and sewer systems for all 19 boroughs. Revised RPs,

² As of February 13, 2014.

incorporating road works, were issued for the secondary systems in each of the boroughs in June 2012.

The biggest challenge in a project of this scope, given the complexity of the municipal structure, is securing the RP's sustainability. It is vital for the city to do everything in its power to make sure the information in the RP is complete and reliable, especially as regards the break-related data used to describe the condition of water lines in terms of break rate (breaks per kilometre per year), a common frame of reference in municipal circles. After several years of considerable effort toward implementing a project of this nature, we feel the time has come to ensure that the Service de l'eau possesses reliable data that it can use to prioritize its actions and guide its decisions in order to reduce the annual number of break-related repairs.

2. Purpose and Scope of the Audit

The purpose of this audit was to determine how effectively the data on water line breaks have been compiled with a view to updating the RPs. We also wished to evaluate to what extent the water lines that have sustained breaks had been identified as priority lines in previous RPs.

We began our work in June 2013, focusing mainly on water line breaks that occurred in the secondary and primary systems in 2012. Our audit also took into account information communicated to us up until February 2014. For certain aspects, data prior to 2012 were also considered.

We concentrated on the DGSRE and the DEP of the Service de l'eau as well as the Direction des travaux publics in Le Plateau-Mont-Royal, Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs.

3. Summary of Findings

Our audit revealed areas where improvements should be made. The following sections of this report will highlight shortcomings regarding:

- Updating data on water line breaks (Section 4.1):
 - Related to water line break repairs in the secondary water system (Section 4.1.1):
 - Data produced by the audited boroughs³ (Section 4.1.1.1):
 - Not all of the break reports entered in the corporate application are backed by work orders completed by the supervisor in charge.
 - Not all of the water line break repairs are accompanied by a break report entered in the corporate application.
 - Control mechanisms have not been put into place to ensure that the information on water line breaks reported in various sources are reconciled on a regular basis.
 - Mechanisms have not been put into place in all of the audited boroughs to ensure that break reports are inputted into the corporate application in a timely manner.
 - Processing of data by the DGSRE (Section 4.1.1.2.):
 - The number of water line breaks repaired by the boroughs in 2011, 2012 and 2013, as reported in various sources, were not validated, thus preventing the necessary corrections from being made.
 - An update process has not been formally implemented within all the business units.
 - Related to water line break repairs in the primary water system (Section 4.1.2.):
 - Not all of the break repair data are submitted to the unit responsible for updating the digitized systems and developing the next RP.
 - An update process has not been formally implemented.
- Data used for analysis and correlation purposes (Section 4.2):
 - The DGSRE's needs in terms of the data required to document water line breaks in detail (e.g., failure types, repair types, causes) have not been communicated to the boroughs.
 - The number of water line break repairs carried out in previous years for each borough differs from report to report.
 - A compilation of the direct and indirect costs for all repairs made to water lines is not available.
 - There are no reports that chart the number of water line breaks over the years or that match up this figure with the corresponding costs for emergency repairs and planned work.
 - The DGSRE is not currently able to conduct analyses and establish correlations on the basis of the data produced by the boroughs.

³ Le Plateau-Mont-Royal, Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs.

4. Detailed Findings and Recommendations

Best practices in municipal infrastructure management indicate one of the signs of decaying water assets is frequent breaks as a result of corrosion, material degradation, poor installation practices, manufacturing defects or unsuitable operating conditions. High leakage rates attributable to pipe corrosion or deteriorating joints also play a role in accelerating the aging process.

Improving the condition of the water system is therefore contingent on reducing the number of water line breaks and lowering leakage rates. This requires thorough knowledge of the system to identify the pipes due for rehabilitation, replacement or repair, as well as those that need to be monitored.

The Service de l'eau uses water infrastructure RPs to identify which water lines are a priority in terms of rehabilitation and replacement work. The decision-making criteria employed to draft these RPs are based, to varying degrees, on the age of the water lines versus their expected service life, their length, their diameter, the materials they are made of, the priority bestowed on the sectors where they are located and, finally, their break repair history.

Physical factors (age, length, diameter, material) were identified and compiled for the first RP and inputted into the corresponding decision trees. In terms of prioritization, water lines are divided into three categories based on the economic and social impacts on the community of a service disruption or an action resulting in situations that are unacceptable to the public. As for the history of water line breaks (in terms of numbers), this can be useful in qualifying their condition. Although information was compiled when the first and second RPs were drafted, data collection must be carried out on a continuous basis in preparation for future versions. Since these data help determine the system's overall state of deterioration and inform decisions regarding planning and timely response, Service de l'eau users must be assured that they are complete and reliable. This requires the existence of and adherence to a formal process for updating data involving all concerned parties.

Furthermore, and again with a view to reducing the number of water line breaks and improving the overall condition of the system, it is important to gain a thorough understanding of the breaks that do occur by compiling complementary data (e.g., causes and types of breaks) in addition to the number of breaks repaired. The availability of these data makes it possible to conduct analyses and establish correlations between them as well as with other data (e.g., physical factors). These findings make it possible to pinpoint the necessary actions before breaks occur. In order to be useful for planning purposes, these analyses must be backed by complete and up-to-date complementary data.

We began our audit by evaluating the process put into place by the Service de l'eau to update data on water line breaks with a view to ensuring the sustainability of the RP, for both the secondary and primary systems. We then calculated the percentage of breaks that occurred in water lines identified in previous RPs. We also examined whether the Service de l'eau had access to the necessary complementary data to establish correlations and thereby target their efforts.

4.1. Updating Data on Water Line Breaks

The roles and responsibilities of the individuals involved in a management process must be clearly defined and communicated in order to ensure all information is complete, reliable and up to date. In a complex organizational structure, easy-to-use tools must be available, and the concerned staff members must be properly trained and supervised to ensure the quality of the information produced. Moreover, controls must be set up to maximize the reliability of the compiled data, since they will help guide subsequent planning and decision making.

As regards the data update process implemented by the Service de l'eau, work began on a structure for updating essential information in December 2009, as part of the water, sewer and road infrastructure RP project. The main goal of this structure was to provide the city with the tools, processes, procedures and guides necessary to ensure data quality and integrity, update information and secure the RP's sustainability. The Service de l'eau has defined "integrity" and "quality" as concepts that refer to the completeness, consistency, timeliness and validity of data for a specific use. The Service de l'eau has also stressed that data must be reliable, accurate, thorough and relevant with respect to the intended use.

Managers from each of the directorates concerned were responsible for promoting the use of and compliance with the processes and tools developed to ensure that essential asset management information was being updated in their respective units. These managers were the heads of Production de l'eau potable,⁴ Gestion stratégique des réseaux d'eau, Épuration des eaux usées and Transports.⁵ They were in charge of appointing representatives to a data update committee, the purpose of which would be to monitor and develop processes for updating essential asset management information. In addition to the representatives of each of these directorates, the data update committee, reporting to the RP project manager, also comprised representatives of the Direction des systèmes d'information,⁶ the Division de la

⁴ Now known as the "Direction de l'eau potable."

⁵ Now known as the "Direction des infrastructures," under the authority of the Service des infrastructures, du transport et de l'environnement" (SITE).

⁶ Now known as the "Service des technologies de l'information."

géomatique⁷ and the Bureau de projets.⁸ Working committees were formed for each of the specified processes, including the process concerning water line breaks.

A guide stemming from the work done by the various committees and dedicated specifically to updating secondary system information was developed in November 2011. This guide, the purpose of which was to ensure a level of consistency in the approach to data and best practices, contains a section on entering information on water line breaks in order to update the system status. The most recent version of the guide provided to us for our audit was dated June 2012. In the following paragraphs, we will outline the contents of the section that deals with water line breaks.

To better understand the process, however, it is important to point out that, since May 2012, the RP has been the responsibility of the DGSRE's Division du plan directeur. The Division's responsibilities include developing the tools required to review RPs. It is also in charge of gathering data on the condition of the water and road systems.

The DGSRE is composed of four divisions of the Gestion stratégique des réseaux d'eau, i.e., the Unité Nord, Unité Sud, Unité Est and Unité Centre. The divisions' duties include planning the infrastructure work to be carried out on secondary systems, allocating financial resources from the water fund to these projects and supervising their execution by the boroughs or the Direction des infrastructures. Each division must also, in conjunction with the corresponding boroughs, implement secondary water system asset management schemes.

First, in the parts of the guide that deal with water line breaks, the main input in terms of break-related data can be found in the break report, which is available in a corporate application in the borough information system (BIS). The previous version of this guide (November 2011), however, provided for the possibility of the boroughs' using data from Excel files, or even work orders, to produce break-related data.

Second, the guide outlines the roles and responsibilities of the various stakeholders involved in the main stages of the update process, as described in Table 1.

⁷ Under the authority of the SITE's Direction des infrastructures in the current structure.

⁸ This has not existed since the June 2012 RP was released.

Table 1 – Roles and Responsibilities of the Stakeholders Involved in Updating Water Line Break Data

Stage in the update process	Unit in charge
Producing data	Boroughs: <ul style="list-style-type: none"> • Ensure break-related information is inputted using the designated break report. • Oversee the quality of data entered in the break report available in the BIS.
Monitoring data gathering operations	DGSRE – Division du plan directeur: <ul style="list-style-type: none"> • Using the data available in the BIS, contact resource persons for the DGSRE units to enter, validate or change break-related information or request additional details.
Processing data	DGSRE – Divisions de la gestion stratégique des réseaux d'eau (Unité Nord, Unité Sud, Unité Est and Unité Centre): <ul style="list-style-type: none"> • Act as a liaison between the Division du plan directeur and the boroughs. • Obtain information from boroughs and contact persons.
Posting information in the spatial geographic information system (SGIS) ⁹ and transferring it to the databases used to prepare the RP	Service des technologies de l'information (STI).
Validating data	DGSRE designated resource persons.
Ensuring compliance of georeferenced breaks	Division du plan directeur.

The update guide stipulates that the following minimum information is required when updating break-related data:

- date of break (date of repair¹⁰);
- the break's segment number or location in the water system section;
- pipe diameter;
- type of pipe.

Finally, concerning the data transmission timeframes, the guide stipulates that, as of April 2012, the Division du plan directeur must make a copy of the information contained in the BIS concerning the previous month's breaks. A data distribution timeframe is also included. Accordingly, these breaks must be processed by the Division du plan directeur and posted in the SGIS within 30 days of data collection for breaks listed in the BIS. In the previous

⁹ Computer application for the acquisition, storage, analysis, sharing and management of geographical data, specifically those in the Service de l'eau's digitized systems. This application makes it possible to use graphic queries to analyze data for planning purposes.

¹⁰ Added in the June 2012 version.

version of the guide (November 2011), breaks that were not entered into the BIS were not posted in the SGIS until the end of the year.

Based on the information we obtained, the update guide was sent to the heads of the DGSRE's divisions of the Gestion stratégique des réseaux d'eau (Unité Nord, Unité Sud, Unité Est and Unité Centre) so they could encourage the boroughs to update the data. The guide is also available in the SGIS documentation.

It should be noted that, at the time of our audit, break reports were being generated by a corporate application known as [TRANSLATION] "Water Main Break," which was part of the BIS and intended for use by the boroughs. Although the title of the report in the application is [TRANSLATION] "Details of Work Performed – Water Main Break," we will refer to it as a "break report" for the purposes of this audit report. Besides the report number, which is automatically generated by the application, the break report contains the following fields:

- Borough;
- Address;
- Leak or break;
- Location of the break: water main, lateral main, fire hydrant connection, service line (city portion or private portion);
- Date break/leak detected;
- Date repairs made;
- Physical features of the water line: diameter, type of pipe, type of pipe lining, type of joint, pipe wall thickness;
- Break-related details: probable cause, type of repair, type of failure;
- Type of soil;
- Soil and pipe samples;
- Presence of external or internal corrosion;
- Comments;
- Drawings.

As we can see, the minimum required information specified in the update guide is less exhaustive than the information contained in the break report. This can be explained by the fact that the purpose of the minimum requirements is to update the database connected to the RP, whereas the additional information in the break report is used to better understand the situation and to conduct analyses and establish correlations. This complementary information touches on such aspects as the nature and cause of the break as well as the type of repair work undertaken. At first glance, this situation may lead to a lack of consistency from one borough to the next, as some administrations may stick to the minimal requirements

whereas others may be more thorough in their approach. We will see in Section 4.2 whether our concerns are founded.

Although DEP representatives took part in the initiatives undertaken by the update committee, a guide focusing specifically on water line breaks in the primary system has not been drafted to formalize the update process for the various stakeholders.

In order to evaluate to what extent the compilation of water line break data provides the Service de l'eau with complete, reliable and up-to-date information, with a view to ensuring the sustainability of RPs, we first reviewed the implementation of the process outlined in the secondary system update guide. This entailed examining the key steps in the process, i.e., data production by the boroughs and processing by the DGSRE up until their posting in the SGIS.

Then, although a formal data update process has not been developed for the primary water system, we nevertheless examined the compilation of water line break data in this system in order to establish a history and ensure the digitized systems are updated in preparation for the next RP.

4.1.1. Water Line Break Repairs in the Secondary Water System

According to the responsibilities outlined in the update guide, the data on water line breaks in the secondary water system are to be produced by the boroughs. Prior to 2012, boroughs were encouraged to use the break report available in the BIS for this purpose, but they were also allowed to generate the required data via Excel spreadsheets or even work orders. As of 2012, however, boroughs are **required** to use the break report, which represents the first source of inputted data in the update process. Moreover, as indicated in the guide, it is incumbent upon each borough to control the quality of the information provided in this break report.

To evaluate the production of water line break data for the secondary water system and the quality of this information, we selected three boroughs from an initial overview of the number of break repairs carried out in 2012. Based on the information obtained from the DGSRE's Division du plan directeur as of June 13, 2013, 900 breaks were repaired by the 19 boroughs in 2012. See Appendix 6.1 for a breakdown of these repairs on a borough-by-borough basis.

The three boroughs we picked were Le Plateau-Mont-Royal (119 breaks), Mercier-Hochelaga-Maisonneuve (86 breaks) and Saint-Laurent (79 breaks). These boroughs were

linked to three different divisions of the Gestion stratégique des réseaux d'eau, namely the Unité Centre, Unité Est and Unité Nord, respectively.

4.1.1.1. Data Produced by the Boroughs

4.1.1.1.A. Background and Findings

In each of the boroughs, most of the water system repair work is carried out by a team assigned specifically to this task (water system team), which reports to the Division de la voirie, under the purview of Direction des travaux publics. Most of the work done by the team focuses on the secondary water system. Repairs of this nature are performed not only on water lines, but also on valves, service lines and fire hydrants. The team is occasionally required to work on the primary water system as well. When the borough has the necessary equipment at its disposal to do so, repairs are done on an in-house basis. However, in cases where specialized expertise or equipment is needed (e.g., for prestressed concrete cylinder pipes), the work is outsourced to a contractor and the corresponding agreement is overseen by the DEP. Even in these circumstances, however, the borough is in charge of preparing the operation and restoring the site to its normal state afterward.

We will begin with a description of the key steps that the boroughs must carry out before completing the break reports that will be used to update the BIS.

The process starts when a break or a leak is detected. The leak detection technician on the borough's water system team goes to the site to locate the problem and assess the nature of the work to be done. Based on the technician's report, the supervisor in charge of water system work (water system supervisor) determines the level of urgency of the work to be performed. The resulting diagnosis determines which assets require repair: water lines, valves, service lines or fire hydrants.

A work order, which is referred to by a variety of names depending on the borough, is then prepared by the water system supervisor to assign the necessary tasks to the work crews. In the case of Le Plateau-Mont-Royal borough, this work order is called a "demande de travail" (work request). In Mercier-Hochelaga-Maisonneuve borough, it is an "ordre de travail" (work order), and in Saint-Laurent borough, it is a "requête de travail d'excavation" (excavation work requisition). These forms must be completed by the supervisor throughout the process, thereby ensuring the work is fully and properly documented.

In the three audited boroughs, the supervisor or a technician enters these work orders into a computer application, either to track the progress of the work or to prepare invoices for the

DGSRE. In Le Plateau-Mont-Royal borough, this is done in the “FileMaker Pro” application, whereas Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs both use an electronic spreadsheet (Excel). There is one notable difference in Saint-Laurent borough, however: once the repair work is completed, the water system supervisor fills out another form by hand known as the [TRANSLATION] “Water Leak Repair Log,” the contents of which are somewhat comparable to those of a break report.

When the repairs are finished, the information entered into the work request, work order or repair log by the water system supervisor is then inputted into the BIS corporate application. This is where the break report must be entered for all repairs carried out by the water system teams. When the data are entered into the application, in most cases by office staff, a box must be checked off to indicate the location of the break (lateral line, service line—private or city portion, agglomeration line or a fire hydrant connection).

Although the work orders used by the water system teams vary from one borough to the next, we nevertheless observed that, for water line repairs, they contain not only the basic information required by the DGSRE in accordance with the update guide for digitized systems (repair date, break location, pipe diameter and material), but also complementary data concerning:

- the nature of the break (e.g., circumferential/longitudinal break, hole);
- the cause of the break (e.g., age, frost, ground settlement);
- the nature of the repair work performed (e.g., description and quantity of materials used, names of employees, tools used).

Needless to say the information in these break reports is very important in meeting the DGSRE’s needs, both for updating the RP-related databases and for conducting analyses and establishing correlations.

Considering how important data production is, we started by checking the source documents (i.e., work requests, work orders or excavation work requisitions) to ensure they were all accounted for. However, we were not able to confirm this, either because the source documents were not pre-numbered or because the numbering system used was not specific to water system operations.

In Le Plateau-Mont-Royal borough, work requests were filled out manually using forms that were not numbered. The information in these requests was entered into the computer application (FileMaker Pro) based on the date the site was identified, without any reference to a numbering system of any kind. The source document used in Saint-Laurent borough (excavation work requisition) was not pre-numbered either. Although a manual numbering

system is used in the borough's [TRANSLATION] "Water Leak Repair Log," this document is produced only once the repair work has been completed. In Mercier–Hochelaga-Maisonneuve borough, numbers are assigned to work orders when they are entered in the designated Excel spreadsheet, but this system applies to all operations undertaken by the Division de la voirie. Because the numbers do not refer specifically to the water system team's work orders, we could not be certain that the source documents were all accounted for. Because there is no system in place to control the source documents, there is a risk that some were not entered in the boroughs' computer applications or, for that matter, in the BIS corporate application. We were therefore unable to confirm that the source documents were all accounted for.

It is important to recall that the Division du plan directeur uses the break report information entered in the BIS to update the digitized systems, which will ultimately be used to develop the next RP. To ensure that all water line break repairs were inputted into the BIS, we compared the lists of the actions performed as they appeared in the computer applications used by the three boroughs with the list of break reports in the BIS, with a specific focus on reports dealing with water line repairs.

As regards the lists generated by the boroughs' computer applications, the list for Le Plateau-Mont-Royal borough contained 232 actions undertaken in relation to the water system in 2012. This included work on water lines, as well as service lines, valves and fire hydrants. For Mercier–Hochelaga-Maisonneuve borough, we were provided with two lists: one for water lines (134 actions) and another for other work done on the system (158 actions). Finally, for Saint-Laurent borough, a list entitled [TRANSLATION] "Water Leaks, City Portion" was submitted, covering work on water lines as well as service lines, valves and fire hydrants (79 actions). For the purposes of our comparison, we used these lists generated by the boroughs' computer applications to extract information on work related exclusively to water lines.

For break reports entered into the BIS by the boroughs, we obtained a file containing the information inputted up until September 17, 2013, from the DGSRE's Division du plan directeur.

A comparison of the number of breaks in these two sources for the three audited boroughs revealed differences that raise questions about the use of the BIS corporate application as well as the completeness of the data contained in the computer applications used by the boroughs (see Table 2).

Table 2 – Comparison of the Number of Water Line Breaks as Reported in Various Sources by the Boroughs – 2012

Borough	Number of breaks		
	Computer application used by the borough ^[a]	Corporate application in the BIS ^[b]	Difference
Le Plateau-Mont-Royal	33	121	88
Mercier-Hochelaga-Maisonneuve	134	113	(21)
Saint-Laurent	62	59	(3)
Total	229	293	64

^[a] Le Plateau-Mont-Royal borough: FileMaker Pro application; Mercier-Hochelaga-Maisonneuve and Saint-Laurent boroughs: electronic spreadsheet (Excel).

^[b] Data entered from break reports generated by the application for use by the DGSRE.

To better understand these differences, we took a closer look at the breaks included in each of the lists. This examination revealed two types of differences: breaks entered in the BIS but not in the boroughs' computer applications, and breaks entered in the boroughs' computer applications but not in the BIS (see Table 3). Following an analysis of both types of differences, we ascertained that there were problems and developed recommendations to improve the existing controls in the boroughs and prevent such situations from reoccurring. As for the issue of a higher or lower number of water line breaks in the BIS application, given that these differences have an impact on the data posted in the SGIS and, by extension, on the information used to develop the next RP, we will address this topic from the perspective of the DGSRE's data validation activities in Section 4.1.1.2.

Table 3 – Differences in the Water Line Breaks Entered in the BIS and the Boroughs' Computer Applications – 2012

Borough	Number of breaks		
	Entered in the BIS but not in the boroughs' computer applications	Entered in the boroughs' computer applications but not in the BIS	Difference
Le Plateau-Mont-Royal	98	10	88
Mercier-Hochelaga-Maisonneuve	16	37	(21)
Saint-Laurent	5	8	(3)
Total	119	55	64

For the first type of difference—water line breaks entered in the BIS but not in the boroughs' computer applications—we observed, as indicated in Tables 2 and 3, that 41% (119/293) of the water line breaks entered by the three boroughs in the BIS were not entered in their own computer applications. Because the water line break information in the BIS is used to update the digitized systems and develop the next RP, we attempted to corroborate that this information corresponded to actual water line breaks. We were able to do so by consulting the boroughs' work requests, work orders or water leak repair logs, or by obtaining other

evidence. Table 4 outlines our findings. The information we obtained shows that, in actual fact, water line breaks were involved in only 11% of these cases (13/119).

**Table 4 – Water Line Breaks Entered in the BIS
but Not in the Boroughs' Computer Applications – 2012**

Borough	Number of breaks			
	Difference	Evidence supporting water line break	No evidence supporting water line break	Evidence refuting water line break
Le Plateau-Mont-Royal	98		14	84
Mercier-Hochelaga-Maisonneuve	16	13		3
Saint-Laurent	5			5
Total	119 [100%]	13 [11%]	14 [12%]	92 [77%]

In 12% of these cases (14/119), all in Le Plateau-Mont-Royal borough, our audit did not reveal any evidence of water line breaks. For some of the break reports in the BIS, the borough was not able to produce the corresponding work requests to justify the existence of the breaks. For others, even though we were able to match up break reports and work requests, the information they contained was not sufficient to show that there had in fact been a water line break (e.g., a lack of information on the nature of the break or the work carried out). We believe that the borough entered the break reports in the system without having sufficient evidence (i.e., a duly completed work request) to support that they were indeed water line breaks. Given the situation, we feel that these breaks should not be included in the databases used to update the RP. It is our view that control mechanisms must be put into place to ensure that all the break reports entered in the BIS are backed by duly completed work requests that prove that water line breaks are involved.

Finally, our audit showed that in 77% of cases (92/119), the repairs made did not involve local water lines:

- A large number of errors occurred in Le Plateau-Mont-Royal borough when the break reports were entered in the BIS corporate application. As mentioned earlier, all the work carried out on water assets is inputted in the BIS application based on the water line break reports generated by the system. A box must be checked to indicate whether the break involves a local water line, a service line (private or city portion), an agglomeration line or a fire hydrant connection. Accordingly, 81 break reports were checked as being work on local water lines while they should have been checked as work on service lines. Although this situation was detected by the DGSRE's Division du plan directeur in June 2013 and corrected in November 2013, this mistake could have led to water line breaks

being erroneously inputted into the databases used to update the RP. The information produced by the borough was therefore unreliable.

- A validation operation performed in Le Plateau-Mont-Royal borough by a staff member of the Division de la gestion stratégique des réseaux d'eau (Unité Centre) showed three instances of mistakenly identified water line breaks.
- Several errors in interpretation occurred when the break reports were being inputted. In Saint-Laurent borough (five cases) and Mercier–Hochelaga-Maisonneuve borough (three cases), these break reports were entered into the BIS and attributed to local water lines, whereas the Excel spreadsheets and the original forms (work orders or water leak report logs) clearly indicated that they were not water line breaks. Similar to Le Plateau-Mont-Royal borough, these are mistakes in interpretation that yielded unreliable results. We feel that these breaks should not be taken into consideration in the databases used to update the RP.

As mentioned earlier, office employees use work requests, work orders or water leak repair logs to enter break reports into the BIS. In order to avoid any interpretation on their part, we feel that the documents produced by the water system teams should clearly indicate all the necessary details so that the inputting process can be complete and error-free. Despite their best intentions, the staff members who enter the data are not always well versed in water infrastructure matters, making it more difficult for them to interpret the source documents. They must be provided with the appropriate support to ensure the information produced is complete and reliable. We also feel that control mechanisms must be introduced at the borough level so that the number of water line breaks is identical from one source to the next, thereby ensuring that the information submitted to the DGSRE is complete and reliable.

For the second type of difference identified in Table 3, i.e., water line breaks that are not in the BIS but are in the lists produced by the boroughs' computer applications, it is possible that these breaks should have been conveyed to the DGSRE. To confirm this risk, we sought out evidence that these were indeed water line breaks. Table 5 presents a detailed summary of the results of our work.

**Table 5 – Water Line Breaks Not Entered in the BIS
but Entered in the Boroughs’ Computer Applications – 2012**

Borough	Number of breaks			
	Difference	Evidence supporting water line break	No evidence supporting water line break	Evidence refuting water line break
Le Plateau-Mont-Royal	10	1	7	2
Mercier–Hochelaga-Maisonneuve	37	17	4	16
Saint-Laurent	8	8		
Total	55 [100%]	26 [47%]	11 [20%]	18 [33%]

For water line breaks in the computerized lists used by the boroughs, but not in the list produced by the BIS corporate application, our audit provided evidence that 47% of these cases (26/55) corresponded to actual water line breaks. Most of these cases were in Mercier–Hochelaga-Maisonneuve borough, and borough authorities acknowledged that some breaks had not been entered into the BIS. The update guide, however, requires the boroughs to enter all break reports in the BIS for all water line repairs, in order to ensure complete information is provided to the DGSRE. Most of the other breaks were in Saint-Laurent borough and can be attributed to an error in interpretation at the time of input. These operations were identified as service line breaks rather than water line breaks, which they had been clearly identified as in the water leak repair log. In both cases, if the DGSRE’s Division du plan directeur applies the update process as outlined in the guide, these breaks will not be incorporated into the RP update process. As we pointed out previously, controls should be implemented to ensure that the number of water line breaks reported in the various sources is identical. We feel that these breaks should be taken into account in the digitized systems used to post information in the SGIS and update the RP.

Furthermore, in 20% of the cases (11/55), which are split between Le Plateau-Mont-Royal and Mercier–Hochelaga-Maisonneuve boroughs, there is no evidence that these were actually water line breaks, because the boroughs were not able to provide a duly completed and approved work request or work order to corroborate the actions that were carried out. Based on the information we obtained, there are two possible explanations: either the work requests or work orders had not been prepared when the work was determined, or the paperwork was misplaced. If the actions entered in the boroughs’ computer applications did not correspond to reality, this raises questions as to the degree of the applications’ use. However, if these operations were actually water line breaks, that means the DGSRE did not receive complete information. If the computer applications are not supplied with complete, reliable information, they are of little use. As we stated earlier, it is our view that full files must be kept for all work entered into these computer applications.

Finally, in 33% of these cases (18/55), we found evidence, in Le Plateau-Mont-Royal and Mercier–Hochelaga-Maisonneuve boroughs, that the operations in the lists produced by the boroughs' computer applications did not, in actual fact, involve water line breaks. It was therefore fitting that they not be entered into the BIS as local water line breaks. According to the information we obtained, some actions are entered in the boroughs' computer applications as soon as an initial diagnosis is made. This diagnosis may change over the course of the project (e.g., what was thought to be a water line break may in fact be a service line break). Considering that these computer applications are used to monitor work to be carried out and that they make it possible to draw comparisons with the break reports in the BIS, we feel that the data they contain must be kept up to date.

As concerns the timing of entering water line breaks in the BIS corporate application for repairs carried out in 2012, we observed that Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs inputted break reports in the system at various times throughout the year. For Le Plateau-Mont-Royal borough, however, the inputting was done between fall 2012 and January 2013, not only for break reports for repairs carried out in 2012, but also for break reports for repairs carried out in 2009, 2010 and 2011, for which a backlog had accumulated. Since there were errors in the entry of the 2012 break reports, we believe that there is a strong possibility that the 2010 and 2011 figures are similarly flawed. Because these mistakes are likely to have an impact on the breaks that will be taken into consideration to develop the next RP, we feel that the borough should check the break reports as entered so that the DGSRE can be assured of the quality of the corresponding data. We will address the issue of data validation by the DGSRE in Section 4.1.1.2.

For the year covered by the audit (2012), Le Plateau-Mont-Royal borough fared less well than the two other boroughs in terms of data entry and file creation. We find this situation to be unacceptable, especially given that the DGSRE had granted an additional budget to the borough in 2010, 2011 and 2012 via partnership agreements, to cover the salaries of leak detection and data collection technicians and a supervisor.

During our audit in Le Plateau-Mont-Royal borough, we were unable to meet the employees who held these positions in 2012. The individuals in question had either left their jobs or were on an extended absence. However, we observed that new employees had been hired in 2013. According to the information we obtained, after mistakes in interpretation were detected in the break reports entered in 2012, a staff member from the Division de la gestion stratégique des réseaux d'eau—Unité Centre was assigned to the borough two days a week for data production purposes beginning in fall 2013. This new approach was too recent for us to evaluate during our audit.

In conclusion, we observed control-related shortcomings in terms of file documentation, data entry into the boroughs' computer applications and the inputting of break reports into the BIS. These shortcomings have had some major consequences for the Division du plan directeur, in that numerous water line breaks went unreported, while other cases were reported when they should not have been. In both instances, the information provided was neither accurate nor complete, thereby jeopardizing overall data reliability. In our opinion, the boroughs need to work with the DGSRE to validate the break repairs and thereby ensure the quality of the information produced.

We also noted that the data required by the DGSRE were entered three or even four times in different forms or applications, which takes extra time and resources and increases the risk of error. We believe that improvements could be made in the tools available to the boroughs in order to standardize the computer applications used and link these with the BIS corporate application. According to the information we obtained, an IT development project is reportedly in the works with the STI to standardize the break report. This would incorporate data entry in the field using a laptop computer and would make it possible to transfer data into the digitized systems for posting in the SGIS and, ultimately, for inclusion in the next RP. This project would reduce the risk of error and cut down on data production times, provided that all boroughs comply. In the meantime, as long as the current data production process used by the boroughs remains in place (work order, in-house application, corporate application), control mechanisms must be set up to ensure the boroughs produce quality information for use by the DGSRE.

4.1.1.1.B. Recommendation

We recommend that Le Plateau-Mont-Royal and Mercier–Hochelaga-Maisonneuve boroughs implement control mechanisms to ensure that:

- **all break reports entered in the designated corporate application are supported by a duly completed work order approved by the supervisor in charge;**
- **a break report is inputted into the designated corporate application every time a repair on a water line is carried out;**

in order to produce all the data that is needed by the Direction de la gestion stratégique des réseaux d'eau and that will ultimately be used to update the response plan.

Business units' responses:

LE PLATEAU-MONT-ROYAL BOROUGH

[TRANSLATION] Check the break report in collaboration with the DGSRE; ensure it is properly completed and incorporates the information gathered (requests for service – residents [RFSs]). (Planned completion: April/May 2014)

Train managers and employees and impress upon them the importance of completing this report properly for all infrastructure work done in the field. (Planned completion: May 2014)

Inform and educate employees with regard to the importance of entering data using the appropriate technical terms for each activity. (Planned completion: May 2014 and ongoing)

Develop an internal procedure and ensure monthly follow up of these reports. (Planned completion: May 2014)

MERCIER–HOCHELAGA-MAISONNEUVE BOROUGH

[TRANSLATION] Implementation of control mechanisms to ensure that:

- *all break reports entered into the corporate application are systematically supported by a work order completed by the supervisor or employee in charge and are numbered in a specific way so that all files concerning a given operation bear the same alphanumeric code;*
- *break reports are entered into the designated corporate application on a weekly basis every time repairs or other operations are performed on a water line. (Planned completion: April 2014)*

4.1.1.1.C. Recommendation

We recommend that Le Plateau-Mont-Royal, Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs periodically reconcile their water line break data as reported in various sources (corporate application, boroughs’ electronic applications) in order to ensure that the information provided to the Direction de la gestion stratégique des réseaux d’eau is reliable.

Business units’ responses:

LE PLATEAU-MONT-ROYAL BOROUGH

[TRANSLATION] Develop a monitoring tool to ensure that no work requests are overlooked. (Planned completion: April/May 2014)

Follow up monthly, compare data and make any necessary corrections. (Planned completion: May 2014)

As soon as a discrepancy is detected, make the required corrections and inform the manager. (Planned completion: May 2014 and ongoing)

Post teams’ productivity results on the notice board to encourage good practices. (Planned completion: June 2014)

MERCIER-HOCHELAGA-MAISONNEUVE BOROUGH

[TRANSLATION] Update water line break data from various sources (corporate application, boroughs' electronic applications) on a weekly basis using weekly reports prepared by the technician and submitted to the section manager in charge of the work. **(Planned completion: April 2014)**

SAINT-LAURENT BOROUGH

[TRANSLATION] The discrepancy between the breaks compiled by the DGSRE and the information in the BIS can be explained by the fact that we did not record data on leaks on private property in the BIS but rather in the target table submitted to the DGSRE. Our action plan therefore consists in compiling leaks on private property in the BIS (with a special note) so that these discrepancies no longer occur. **(Planned completion: March 2014)**

4.1.1.1.D. Recommendation

We recommend that Le Plateau-Mont-Royal borough ensure that break reports are entered promptly into the designated corporate application, as outlined in the guide developed for this purpose, in order to provide the Direction de la gestion stratégique des réseaux d'eau with accurate information and update the databases used to prepare the response plan.

Business unit's response:

[TRANSLATION] Assign a staff member to follow up on every operation undertaken by crews in the field. **(Planned completion: April/May 2014)**

Train this staff member on how to complete the reports properly. **(Planned completion: April/May 2014)**

Follow up monthly with the DGSRE and make any necessary corrections. **(Planned completion: May 2014)**

Submit quarterly reports to the borough management. **(Planned completion: July 2014)**

4.1.1.2. Processing of Data by the Direction de la gestion stratégique des réseaux d'eau**4.1.1.2.A. Background and Findings**

Using the water line repair data inputted by the boroughs into the [TRANSLATION] "Water Line Break" corporate application in the BIS, the Division du plan directeur then proceeds with its own data entry so that the STI can update its databases in order to:

- post information in the SGIS;
- produce the RP.

As we mentioned in the introduction of this audit report, two RPs have been produced thus far, one in December 2009 and the other in June 2012. The first RP was based on the water line repair history up until December 31, 2008. The second RP took into account data inputted up until December 31, 2010. The next RP slated for 2016 will cover water line break repairs from December 31, 2010, onward.

During our audit, we sought to determine how complete and up to date the information on water line breaks provided to the DGSRE was and how well it fulfilled the DGSRE's needs.

We will start with a description of the main steps involved in the update process that enabled the DGSRE to collect data on the breaks repaired in 2012 until their transfer to the databases. Between January 2012 and June 2013, a technician from the Division du plan directeur gathered the information available in the BIS [TRANSLATION] "Water Line Break" corporate application via files listing all the work inputted by the boroughs by way of break reports. Using this information, the technician located each of the water line breaks in the ArcGIS geographic information system.¹¹ This step consists in entering the geographic location of the breaks, by civic address or intersection, on the corresponding georeferenced water lines, as well as the repair date, so that the break numbers can be generated by the application. Once the breaks are entered in the ArcGIS system, the Division du plan directeur must periodically send break reports to the Division de la géomatique to be transferred to the databases used by the STI for the purpose of posting this data in the SGIS and, ultimately, producing the RP. In this section, we will refer to the breaks transferred to the SGIS/RP databases in this manner as "georeferenced breaks."

Specifically with regard to data collection in 2012, based on the information we obtained, five boroughs¹² communicated information on water line breaks using lists generated by their own computer application rather than the BIS break report. Although this is not compliant with the practices outlined in the new version of the update guide, the technician nevertheless made use of the computerized lists produced by these boroughs for data collection purposes. Besides Le Plateau-Mont-Royal, two other boroughs¹³ forwarded lists generated by their computer application before eventually inputting the break reports into the corporate

¹¹ System composed of various platforms that allow SGIS users to collaborate and share geographic information.

¹² Ahuntsic-Cartierville, Pierrefonds-Roxboro, Villeray–Saint-Michel–Parc-Extension, L'Île-Bizard–Sainte-Geneviève and Ville-Marie boroughs.

¹³ Côte-des-Neiges–Notre-Dame-de-Grâce and Rosemont–La Petite-Patrie boroughs.

application. Although these breaks were entered in the BIS corporate application, it was not done in a timely manner.

In June 2013, while preparing a report on the number of breaks repaired in 2012 for all of the boroughs, the Division du plan directeur sought to ensure the accuracy of the number of georeferenced breaks. Accordingly, the number of georeferenced breaks was compared with the number of breaks reported in various sources, i.e., the break reports inputted in the BIS, the monthly target table produced by the boroughs for the divisions of the Gestion stratégique des réseaux d'eau (Unité Nord, Unité Sud, Unité Est and Unité Centre) and the lists generated by computer applications used in certain boroughs.

This comparison uncovered discrepancies in the number of breaks reported in various sources in 17 boroughs. According to the information obtained, some of the boroughs were questioned about this, but no explanations were given. An investigation must be undertaken to explain why these differences occurred and to allow for the necessary corrections to be made. An initial likelihood analysis comparing the breaks reported in various sources was conducted by the Division du plan directeur. This analysis revealed that, for boroughs using the BIS corporate application, some breaks were not inputted in the application, although they did appear in the other lists that were submitted. The reverse situation also occurred, i.e., breaks that were entered in the corporate application but not in the target table or lists produced by the boroughs using their computer application. As previously discussed, we observed similar situations in the three boroughs we audited (see Section 4.1.1.1).

Among the boroughs where discrepancies were noted, Le Plateau-Mont-Royal raised the most questions, given that the number of georeferenced breaks based on the breaks reported in the BIS (121) was much higher than the number of breaks in the target table (45) and the in-house list (48). The information we obtained indicated that all of the break reports entered by the borough in the BIS with the mention [TRANSLATION] "local water lines" were inputted into the ArcGIS application and, in February 2013, were transferred to the databases used to post information in the SGIS and ultimately produce the next RP. This mistake was not noticed by the Division du plan directeur until June 2013. As mentioned in the previous section, the difference was largely attributable to an error in interpretation. The borough had entered 81 break reports as work on local water lines instead of work on service lines.

For the 40 other water line breaks in Le Plateau-Mont-Royal borough, i.e., the ones where these inputting errors were not made, a staff member at the Division de la gestion stratégique des réseaux d'eau—Unité Centre conducted a validation operation in late September 2013. This involved making sure that the break reports identified by the Division du plan directeur as georeferenced water line breaks did indeed correspond to actual repairs made to water

line breaks. This validation also aimed to ensure that the data entered in these break reports were consistent with those contained in the files and that the breaks in question had been properly entered into the digitized systems. Finally, the number of breaks georeferenced by the Division du plan directeur was compared with the number of breaks presented in the target table submitted monthly by the borough to the Division de la gestion stratégique des réseaux d'eau—Unité Centre.

This revealed that, of the 40 break reports examined, 37 were indeed related to secondary water lines and one involved a primary water line, while the two others were not related to water line breaks. Moreover, a review of the break reports showed that information on the type of repairs was missing and that the data did not always correspond to the information in the file (e.g., date of the end of repair work, pipe diameter). In addition, this validation operation showed that four breaks had been improperly georeferenced by the Division du plan directeur. Finally, the number of secondary water line breaks presented in the target table (45) was overstated, compared with the 37 confirmed breaks.

Although this validation made it possible to review the compliance of the georeferenced breaks, it did not ensure that all of the breaks had been entered in the BIS application and, as a result, transferred to the databases. In our opinion, this exercise should have also confirmed this information. Our audit revealed one additional water line break in Le Plateau-Mont-Royal borough (Section 4.1.1.1) that should have been georeferenced.

As for the 16 other boroughs, although the overview of water line breaks in 2012 also showed discrepancies following the comparison of the number of breaks reported in various sources, validation operations similar to the one carried out in Le Plateau-Mont-Royal borough were not undertaken in 2013.

For Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs, which were covered by our audit, we feel that a similar validation operation is warranted:

- Some water line breaks were not transferred to the databases used to update the RP because they had not been inputted into the BIS (17 in Mercier–Hochelaga-Maisonneuve borough and eight in Saint-Laurent borough). Note that these breaks were still included in the boroughs' computer applications;
- Some water line breaks were not transferred to the databases used to update the RP, despite the fact that they were entered in the BIS (three in Mercier–Hochelaga-Maisonneuve borough);
- Some water line breaks should not have been transferred to the databases used to update the RP (four in Saint-Laurent borough).

Moreover, although we did not focus on any other boroughs during our audit, the fact remains that the 2012 overview of water line breaks revealed discrepancies in the number of breaks reported in various sources. For this reason, we feel that this information should be validated for all of the boroughs. This validation operation should provide the Division du plan directeur with the assurance that the breaks transferred to the databases used to inform the SGIS and update the RP correspond to actual water line breaks and are backed by the appropriate supporting documents. Furthermore, a validation of this nature should make it possible to compare information from different sources to ensure that **all** water line breaks have been taken into consideration in the database update process. Once the differences in the number of breaks reported in various sources have been analyzed, corrections will have to be made wherever necessary.

Although the scope of our audit was limited to water line breaks in 2012, we were concerned about the possible outcome of comparing the number of breaks reported in various sources in 2011. According to the information we obtained, a comparison of this nature had not been performed, which did little to reassure us that all of the breaks repaired that year had been entered in the databases used to update the RP. On the basis of the findings of our audit, we feel strongly that the number of water line break repairs in 2011, as reported in various sources, needs to be compared.

According to the information we obtained, one of the DGSRE's orientations was discussed at a management committee meeting at the end of 2013, concerning the responsibility for validating break-related data. Accordingly, it would seem that the divisions of the Gestion stratégique des réseaux d'eau (Unité Nord, Unité Sud, Unité Est and Unité Centre) are accountable for comparing the results in the target table produced by the boroughs with the information in the corporate application where the break reports are generated. Data related to water line breaks is also validated on a random basis. As this report was being prepared, we learned that this orientation is reportedly awaiting approval by the DGSRE management.

As specifically regards water line breaks in 2011, 2012 and 2013 (since the same approach was applied from year to year), we were made aware of an email sent at the end of December 2013 by the technician in charge at the Division du plan directeur to the engineers and technicians in each of the divisions of the Gestion stratégique des réseaux d'eau, asking them to validate georeferenced breaks, with a proposed deadline of January 15, 2014. As this report was being prepared, the Division du plan directeur had received replies from four boroughs and was still awaiting feedback from the others. It would seem that the exercise is a labour-intensive one, given that it covers the three previous years. We agree that the exercise would have been easier had it been undertaken earlier in the process, but we are nevertheless convinced that the data transferred to the databases must be validated. The

information posted in the SGIS and used to produce the next RP must be reliable. In specific reference to 2012, we have listed the number of georeferenced breaks per borough in Appendix 6.1 to be validated by the divisions of the Gestion stratégique des réseaux d'eau.

Finally, based on the information at our disposal concerning the processing and posting times indicated in the update guide, these guidelines have not been adhered to. As previously mentioned, the guide dictates that in the first week of every month, the technician from the Division du plan directeur must make a copy of the information in the BIS regarding the water line breaks inputted during the previous month. Subsequently, these breaks must be analyzed and reported within 30 business days following the cut-off date for data collection.

We obtained the files transferred to the Division de la géomatique between August 2012 and October 2013. Upon examining their contents, we realized that the break-related data had not been transferred within a reasonable timeframe. Over this 15-month period, there were seven transfers made. Furthermore, we noted that 69 breaks dealt with repairs performed between 2007 and 2010, a significant percentage of which were reported by Le Plateau-Mont-Royal borough. It is our opinion that the Division du plan directeur should have received this information long before 2012. If these data had been sent in a timely fashion, they would have been included in the June 2012 RP, which took into account figures up until December 31, 2010. We also ascertained that more than 1,000 water line breaks repaired in 2011 were inputted by the boroughs between August 2012 and May 2013. Similarly, we feel that the Division du plan directeur should have processed the information concerning these breaks much earlier. Although these data were not included in the June 2012 RP, they will be in the next version, slated for 2016. The fact remains, however, that this break-related information should have been posted in the SGIS and made available to users.

In conclusion, data collection cannot be carried out in a consistent manner because the boroughs do not all adhere to the same update process, as outlined in the update guide (e.g., break reports, submission timeframes). Data completeness and reliability can be assured only if the boroughs are rigorous in their production. Our audit showed discrepancies in 2012 following the comparison of the number of breaks reported in various sources. Questions have since been raised about 2011 and 2013, since the same approach was in place. The boroughs and the divisions of the Gestion stratégique des réseaux d'eau (Unité Nord, Unité Sud, Unité Est and Unité Centre) will have to investigate further to explain these differences. In our opinion, the DGSRE cannot be certain that the water line break data it has are complete and reliable until they have been validated. We believe that the various sources of water line break data must be compared in order to determine which water line breaks should have been transferred to the databases and which ones should not be taken into account. This comparison should cover the years 2011, 2012 and 2013, and any resulting

corrections should be made to ensure that the information in the database is complete and reliable, since these details are posted in the SGIS and will be the basis for the next RP.

In an attempt to make a fresh start in this regard, the DGSRE should formalize its process for updating information on water line breaks and make sure everyone adheres to it. This process will obviously need to outline the roles and responsibilities of the various stakeholders, establish deadlines for producing, collecting and processing data, define the nature and frequency of data validation activities and put forward accountability mechanisms.

4.1.1.2.B. Recommendation

We recommend that the Direction de la gestion stratégique des réseaux d'eau validate the number of water line breaks repaired in 2011, 2012 and 2013, as reported in various sources (corporate application, computer applications used by the boroughs, target tables, databases) and make the appropriate corrections as required so that the data posted in the spatial geographic information system are complete, reliable and conducive to preparing the next response plan in 2016.

Business unit's response:

[TRANSLATION] Water line break data for 2011, 2012 and 2013 will be validated by the DGSRE's management units and incorporated into the next version of the RP slated for 2016. (Planned completion: March 2015)

4.1.1.2.C. Recommendation

We recommend that the Direction de la gestion stratégique des réseaux d'eau formalize its process for updating data on water line breaks and take the necessary measures to impress upon the various business units the importance of adhering to the instructions in the guide concerning this process, particularly those related to:

- the roles and responsibilities of various stakeholders;
- data production, collection and processing timeframes;
- the nature of validation activities;
- the frequency of validation activities;
- accountability;

to ensure complete and reliable data are transferred to the databases for subsequent posting in the spatial geographic information system and use in preparing the next response plan.

Business unit's response:

*[TRANSLATION] A new validation procedure for water line breaks is being developed. It clearly outlines the roles and responsibilities of the various stakeholders involved in entering information on water line breaks. This new procedure will be adopted and disseminated in the next version of the guide for updating digitized systems. **(Planned completion: to be disseminated in June 2014)***

*This new procedure will be implemented as soon as it is released and used for data validation purposes in the years to come. **(Planned completion: June 2014)***

4.1.2. Water Line Break Repairs in the Primary Water System

4.1.2.A. Background and Findings

When the RP was being developed for the primary water system, DEP representatives chose the break rate (breaks per kilometre per year) as the criterion to determine which water lines were to be earmarked for replacement or rehabilitation. Similar to the secondary water system, this information is contingent on a break/repair history that changes over time. An update process must therefore make it possible to access this history in order to produce a new RP when comes time to do so. Moreover, given how important the break history of primary water lines is in the planning process, DEP staff members must have access to up-to-date information in the digitized systems.

As indicated in Section 4.1, although DEP representatives were on the update committee, created in 2009 as part of the RP project, a guide for updating digitized systems covering primary water lines, including a section on water line breaks, has never been prepared, despite the fact that a guide for secondary water lines is available. Based on information obtained from the head of the DGSRE's Division du plan directeur (who was the RP project manager until 2012), a greater priority was placed on updating the secondary systems. The fact that, to date, two RPs have been produced for the secondary systems (in December 2009 and June 2012) compared with only one RP for the primary system in 2009 would appear to corroborate this claim.

Despite the lack of a formal data update process for primary water line breaks, we nonetheless evaluated whether compiling the available data enabled DEP staff members to have access to useful historical information for decision-making purposes and to update the databases with the ultimate goal of producing a new RP.

First, it should be reminded that the primary water system extends throughout the Island of Montréal. The responsibility for the primary water system falls to the urban agglomeration

council, and water line maintenance has been delegated to the city and related municipalities.¹⁴ The city has in turn sub-delegated water line maintenance to the boroughs.¹⁵ Among the maintenance activities covered by these two by-laws are detecting and repairing water line leaks and breaks.

In reality, when a break occurs in a primary water line, the borough or the related municipality, as appropriate, will locate the problem, secure the site, excavate the area and stop the flow of water. If the borough or related municipality is suitably equipped to do so, the related repairs will be done on an in-house basis. In the case of major repairs, however, the borough or related municipality will call upon the services of the DEP's Division de l'exploitation du réseau primaire. In the latter situation, the repair work will be assigned to a contractor pursuant to a framework agreement managed by the Division. Break repairs are therefore executed by the boroughs or related municipalities, or managed by the DEP in the case of work that is contracted out. Consequently, water line break data can come from three different sources.

In the case of water line break repairs done on an in-house basis by the boroughs, the data compilation process used for the secondary water system is the same for the primary water system with respect to creating work files (work orders) and entering them in the boroughs' computer application of choice. In terms of producing data on water line breaks for the purpose of updating the digitized systems, the boroughs enter the break reports in the BIS application, the same way they do with the break reports for the secondary water lines. The basic procedure for entering break reports in the corporate application is covered in the secondary water system update guide. However, the primary water system report contains a box that lets users identify water lines as local or an "agglomeration line." The DGSRE's Division du plan directeur is responsible for collecting the data on primary water line breaks in the BIS application, as it is for the secondary water system. Water line breaks are then inputted into the ArcGIS system for the purpose of updating the corresponding digitized systems.

When water line break repairs are carried out by the related municipalities, the corresponding data can obviously not be produced using a break report in the BIS corporate application because this application is reserved exclusively for use by the city. However, because the operating costs associated with delegating and sub-delegating powers are entirely the responsibility of the agglomeration, an invoice must be submitted to the city. The related municipalities' invoicing records, like the boroughs' invoicing records, are therefore submitted to a member of the technical committee, formed in accordance with the two by-laws. This

¹⁴ Via By-law RCG 05-002.

¹⁵ Via By-law 05-090.

technical committee, which is made up of representatives of the related municipalities and the city, reports to the DEP and is primarily tasked with analyzing the related municipalities' annual reports, as established in the by-laws, and producing a consolidated report for the urban agglomeration council. The submitted reports are subjected to a technical analysis, and invoices to an administrative analysis, before the costs associated with the delegated maintenance activities are reimbursed. Our audit showed that the water line break data that accompanied these invoices were not used to update the digitized systems for the primary water lines. In fact, this information was not forwarded to the DGSRE's Division du plan directeur, which is the body responsible for updating the digitized systems for the secondary water lines.

Finally, as regards outsourced repairs, the DEP's Division de l'exploitation du réseau primaire is responsible for administering a three-year, \$3.3-million contract (2010–2013) for all emergency repairs. Note that the repair work carried out by the contractor can be performed on water lines and valves. A table used to track work orders sent to the contractor is what the Division de l'exploitation du réseau primaire used to provide us with information concerning the compilation of water line break repair data. This table indicates the nature of the work and lists the work orders issued to repair breaks or leaks. Our audit revealed that the water line break data in this table were not used to update the digitized systems for the primary water lines.

We would have expected these data concerning repairs to breaks in the primary water system to be compiled in a single location, but this was not the case. Table 6 has been prepared using the break repair statistics we obtained from all three sources.

**Table 6 – Water Line Break Repairs
in the Primary Water System, by Source of Information – 2012**

Source		No. of breaks repaired
DGSRE Division du plan directeur	Break reports	27 ^[a]
DEP	Invoicing records of related municipalities and boroughs	17 ^[b]
	Work contracted out	18 ^[c]
Total		57^[d]

^[a] City boroughs only.

^[b] Ten breaks in related municipalities and seven breaks in boroughs (including four georeferenced breaks).

^[c] One break in a related municipality and 17 breaks in boroughs (including one georeferenced break).

^[d] Georeferenced breaks excluded.

If we take all the breaks reported in the various sources into account, a total of 57 breaks occurred in 2012.

First, the number of breaks obtained by the Division du plan directeur (27) corresponds to the number of georeferenced water line breaks indicated in the break reports entered in the BIS corporate application by the boroughs. All of these breaks were repaired by the boroughs themselves.

Second, with regard to the leak and break repairs invoiced pursuant to delegation and sub-delegation by-laws (RCG 05-002 and 05-090), we obtained a copy of the report entitled [TRANSLATION] “Summary of Activities Carried Out in 2012 Pursuant to Delegation and Sub-Delegation By-Laws (RCG 05-002 and 05-090).” This report, submitted to the urban agglomeration council in March 2013, referred to 17 invoices for leak and break repairs in the primary water system, as issued by related municipalities (10) and boroughs (7).

Comparing the invoicing records with the list of breaks obtained from the Division du plan directeur reveals that the 10 breaks that occurred in the related municipalities and three of the breaks that occurred in the boroughs were not on the Division’s list. This situation shows that the boroughs issued invoices but did not produce break reports for the repairs in question. Moreover, of the 27 breaks in the list prepared by the Division du plan directeur, only four were included in the report entitled [TRANSLATION] “Summary of Activities Carried Out in 2012 Pursuant to Delegation and Sub-Delegation By-Laws (RCG 05-002 and 05-090)”; the remaining 23 were not in the report. This can mean one of two things: either they were not actual water line breaks, or the boroughs did not issue invoices for these 23 breaks, in which case the information communicated to the urban agglomeration council would be incomplete. An investigation should be carried out to explain these discrepancies.

Third, for the water line break repairs that were contracted out, a table produced by the DEP’s Division de l’exploitation du réseau primaire enabled us to compile the corresponding work orders, for a total of 18 break or leak repairs in 2012, including one in a related municipality and 17 in the boroughs. Of the breaks repaired in the boroughs, a break report was issued by the corresponding borough in only one case. This break was therefore georeferenced by the DGSRE. For the 16 other breaks, the Division de l’exploitation du réseau primaire did not share the details with the Division du plan directeur, which already has the staff in place to process water line break data. During our audit, the manager responsible for the Division de l’exploitation du réseau primaire acknowledged the situation and mentioned that the data would be compiled as of 2014.

Because there has been no formal data update process in place since the production of the RP in 2009, two DEP units and the DGSRE's Division du plan directeur compile information for their own use and do not share the results with one another. As a result:

- The DGSRE's Division du plan directeur, which has trained staff in place to process information on water line breaks and transfer these data to the Division de la géomatique for posting by the STI, did not receive break-related details from the two other DEP units. Consequently, some of the water line break repairs carried out in the primary water system were not incorporated into the digitized systems.
- The SGIS does not give the DEP a complete picture of its system, because not all of the breaks have been incorporated into it since the RP was produced.

In our opinion, it would be advisable to develop a formal update process for water line breaks to ensure practices are adhered to in a consistent manner. Similar to that for the secondary water system, this process should outline the roles and responsibilities of the various stakeholders, establish deadlines for producing, collecting and processing data, require the use of a break report, define the nature and frequency of data validation activities and put forward accountability mechanisms.

The approach that we have described is the same as the one used in past years. As of February 12, 2014, other than the breaks entered into the BIS application by the boroughs, breaks from previous years (January 1, 2009, onward) had not all been collected and processed by the Division du plan directeur. We believe that the water line break data for these years need to be inputted and transferred to the databases so that SGIS users can have access to an up-to-date break history. This updated information is what will be used to produce the next RP and ensure its sustainability.

4.1.2.B. Recommendation

We recommend that the Direction de l'eau potable share all water line break data with the Division du plan directeur to ensure that the details in the spatial geographic information system databases are complete, up to date and ready to be incorporated into the next response plan.

Business unit's response:

[TRANSLATION] The DEP will enter data on all water line breaks into the city's corporate application and will follow the data update guidelines issued by the Service de l'eau. (Planned completion: June 2014)

4.1.2.C. Recommendation

We recommend that the Service de l'eau set up a formal data update process for water line breaks in the primary water system and take the necessary measures to impress upon all of the business units the importance of adhering to these measures. This process should cover:

- the roles and responsibilities of the various stakeholders;
- data production, collection and processing timeframes;
- the use of break reports;
- the nature of validation activities;
- the frequency of validation activities;
- accountability mechanisms;

to ensure that complete and reliable information is transferred to the databases for subsequent posting in the spatial geographic information system and use in preparing the next response plan.

Business unit's response:

[TRANSLATION] The new water line break data validation procedure that is currently under development will apply to related municipalities, boroughs and the management units of the DGSRE and DEP. This procedure will be implemented as soon as it is released and will be used in future to validate the water line break data entered for water mains. (Planned completion: June 2014)

4.2. Data Used for Analysis and Correlation Purposes

4.2.A. Background and Findings

As indicated previously, one of the ways to reduce the number of water line breaks is to identify assets that are in poor condition and need to be replaced or rehabilitated. Another more preventive strategy is to detect water line leaks before any damage occurs. Leak detection makes it possible to plan repairs based on their relative degree of urgency.

The information in the RP determines which water lines need to be replaced or rehabilitated. For the secondary water system, the first RP (December 2009) stated that the water lines due for replacement or rehabilitation were those that exceeded a given threshold in terms of break rate. This threshold varied according to the water line's respective priority level:¹⁶

- Priority level A: high sensitivity level—1.5 breaks per kilometre per year;

¹⁶ Priority levels are determined on the basis of unacceptable economic and social consequences to the public that can result from failures, service interruptions or work on water lines.

- Priority level B: moderate sensitivity level—2.0 breaks per kilometre per year;
- Priority level C: low sensitivity level—3.0 breaks per kilometre per year.

For water lines with the highest sensitivity level (priority level A), priority was given to lines that had exceeded the break threshold as well as those that had reached the end of their service life. As indicated earlier for this RP, the cut-off date for break-related data was December 31, 2008.

For the second RP (June 2012), the decision tree was altered. Although the criterion for replacement or rehabilitation was still based on the break threshold, this threshold was set at two breaks per kilometre per year, regardless of priority level. Service life was no longer taken into account when ranking the water lines identified as priority level A, although it continued to be used to determine the nature of the work to be done (replacement or rehabilitation) for priority levels B and C. The information for this RP was based on break data compiled up until December 31, 2010.

The water lines identified as a priority in the RPs have not yet all been replaced or rehabilitated. We therefore decided to evaluate how many of the water line breaks that occurred in 2012 had been targeted in these RPs. If a line that was repaired in 2012 had been listed in one of the RPs, it was because it had exceeded the break threshold. Conversely, if a line repaired in 2012 had not been listed in one of the RPs, it was because it had not exceeded the break threshold as of December 31, 2008, or December 31, 2010, as the case may be.

In the three boroughs covered by the scope of our audit, we determined that only a small percentage of the water lines where a break occurred in 2012 had been identified in one of the RPs. Table 7 summarizes these findings.

Table 7 – Percentage of Water Lines Identified in an RP that Sustained a Break in 2012

Borough	RP	
	December 2009	June 2012
Le Plateau-Mont-Royal	27%	5%
Mercier-Hochelaga-Maisonneuve	7%	1%
Saint-Laurent	3%	1%

These results also show that a higher percentage of water lines that sustained a break in 2012 were listed in the 2009 RP than in the 2012 RP. This can be explained by the change in criteria used in the decision trees with regard to break thresholds and service life.

Most of the water lines that sustained breaks in 2012 had not been identified in either RP, which means that they had not exceeded the break thresholds, according to the available data. In other words, the RPs had not earmarked these lines for replacement or rehabilitation.

Moreover, every year the DGSRE signs partnership agreements with the boroughs specifying the water and sewer lines that are slated for replacement or rehabilitation. The water lines listed in these agreements were chosen because they were identified in an RP, because they sustained a major break after the RP data compilation cut-off date or because work on adjacent sewer lines made it practical to do both operations at once. We therefore evaluated to what extent water line breaks that occurred in 2012 had been identified in the partnership agreements with the boroughs in question. In the three audited boroughs, we concluded that a small percentage of the water lines repaired in 2012 had been identified as a priority in the 2012 or 2013 partnership agreements. Note that this percentage was not indicated in the RPs either.

Table 8 – Percentage of Water Lines Identified in a Partnership Agreement (2012 or 2013) that Sustained a Break in 2012

Borough	Partnership agreement (2012 or 2013)
Le Plateau-Mont-Royal	8%
Mercier-Hochelaga-Maisonneuve	21%
Saint-Laurent	16%

Therefore, given that most of the water lines that sustained a break in 2012 were not listed in an RP or a partnership agreement, there is every reason to believe that they had not exceeded the break threshold selected as the prerequisite for replacement or rehabilitation work. Based on the criteria set forth by the Service de l'eau, work of this nature is required only when other breaks occur, which may result in inconvenience. This situation raises questions in our minds about the possible correlations between breaks and certain characteristics of these water lines. The borough representatives we met with during our audit mentioned that the age of the water lines was to blame for the breaks. We therefore proceeded to compare the age of the water lines where a break occurred with their expected service life.

According to the information contained in the RPs, the service life of a water line depends on the type of material it is made of and the year it is installed (see Table 9).

**Table 9 – Service Life Associated with Water Line Materials,
Based on Year of Installation**

Service life of materials	Grey cast iron		Ductile iron	
	Before 1940	1940–1965	Up to 1979 ^[a]	After 1979
Minimum	80 years	60 years	60 years	60 years
Probable	120 years	90 years	80 years	80 years
Maximum	175 years	120 years	100 years	100 years

^[a] These figures have been revised since the 2010 RP, in which the service life figures for the three categories were listed as 45 years, 60 years and 75 years, respectively.

Source: Data retrieved from [TRANSLATION] *Integrated Response Plan for Water, Sewer and Road Systems*, Service de l'eau, June 2012.

The following information is derived from the surveys we conducted. In Le Plateau-Mont-Royal and Mercier–Hochelaga-Maisonneuve boroughs, most of the water lines where a break occurred in 2012 were made of grey cast iron. Moreover:

- In Le Plateau-Mont-Royal borough, most of the water lines that sustained a break in 2012 were installed prior to 1940. Nearly half of the lines had exceeded their probable service life, whereas the remainder had reached their minimum service life;
- In Mercier–Hochelaga-Maisonneuve borough, a little more than half of the water lines where a break occurred in 2012 were installed after 1940. None had yet reached their minimum service life. For water lines installed before 1940, they had gone past their minimum service life but had not yet achieved their probable service life. None had yet reached their maximum service life.

In Saint-Laurent borough, our survey sample was composed primarily of ductile iron water lines installed prior to 1979. The others were made of grey cast iron and were installed after 1940. Almost none of the water lines examined had achieved their minimum service life. Their expected remaining life span was therefore relatively long.

We concluded from this that these breaks occur as frequently in water lines that have not yet reached their minimum service life as they do in lines that have gone past this point. It follows that breaks can take place at any time during a water line's service life and that there are other factors at play.

During our audit, we wondered about the possibility of using a process that could help analyze types of failures, repairs and break causes. According to the information we obtained, data that make it possible to qualify and explain a break are significant, as they help elucidate the break, make correlations and, ultimately, influence planning. Accordingly, there may be a connection between the type of failure and the level of deterioration of a water line. In the boroughs, water system teams repair water lines with a view to restoring service as quickly

as possible. They do not feel accountable for analyzing the causes, which they tend to attribute to the same factors: aging pipes, frozen ground, corrosion or improper maintenance.

We noted that the DGSRE's guidelines for producing data on various types of failures and repairs were not clearly stated. The break report that the boroughs are supposed to use in the [TRANSLATION] "Water Line Break" application contains fields to indicate the probable cause of a break, the type of repair and the type of failure. However, as we observed in Section 4.1.1.1 of this report, the data must be present in the source documents before they can be entered in the system. Although the work request form used by Le Plateau-Mont-Royal borough and the work order form used by Mercier–Hochelaga-Maisonneuve borough contain fields where the cause of the break, type of repair and type of failure can be entered, we saw that this information was not documented in most cases, which precluded the data from being entered into the corporate application. In the case of Saint-Laurent borough, although the water leak repair log does not prompt users to indicate the cause of the break, it does provide fields for noting the type of failure and type of repair involved. We observed that this information was indicated when the break report was being entered in the corporate application. In addition, the cause and nature of the break and the nature of the failure are not identified as minimum information requirements in the update guide, which has created confusion among the boroughs and undermines the overall consistency of the data presented.

During our audit, we ascertained that the DGSRE's Division du plan directeur was not receiving complete data that would allow it to analyze the various factors contributing to water line failures and deterioration, making it impossible to establish correlations among various elements. We believe that clear guidelines must be imparted to the boroughs so they can include break-related details in the data they produce. We believe that break reports are the best channel for this information in order to promote consistency in the boroughs' output.

As we indicated at the beginning of this section, another way to lower the number of breaks is to detect water line leaks before any damage occurs. This is a "preventive" approach, which makes it possible to plan actions based on their relative level of urgency. It also allows for the monitoring of certain water lines. But most important, detection helps minimize emergency repairs.

A leak detection structure was implemented for the secondary water system by the DGSRE (procurement of trucks, hiring of staff members, provision of training) and systematic leak detection operations began in the fall of 2013. According to the information provided to us, systematic screening has been set up in Montréal-Nord borough, and ad hoc detection operations have been carried out in seven other boroughs. We hoped to obtain a report on

the results of these initiatives, in terms of the number of leaks detected, their level of priority and their repair status. As of January 16, 2014, a report listing the number of leaks detected by the new team had not yet been prepared. According to information received from the head of the DGSRE's Division du plan directeur, as of that date the leak detection technicians had covered 8% of the territory and found 27 leaks in water lines and 23 leaks in service lines. Subsequent follow-up for these detected leaks is then turned over to the boroughs, which means that information on the repairs will not be available to the DGSRE until the corresponding break reports are issued.

For the primary water system, the DEP has signed three agreements with private contractors since 2007, for a total of \$1.8 million, to detect leaks in iron and steel water lines. According to the information we obtained, nearly 80% of the water lines (in terms of kilometres) are made of iron or steel. The remaining 20% are made of C301 concrete. Between November 2007 and October 2013, 30 leaks were detected in close to 30 km of water lines. These leaks have been categorized according to size: nine large, four medium, seven small, seven very small and three uncategorized. Eighteen of these lines were replaced, nine were repaired and three are currently slated for repairs. Note that three of these leaks were detected in 2012, two of which have been repaired.

Finally, as mentioned earlier in this section, leak detection, along with replacement and rehabilitation, should make it possible to reduce the number of water line breaks. In the short term, however, it is expected that the number of breaks will rise, since crews will be called upon to handle both emergency repairs and preventive repairs resulting from leak detection operations. But the number of emergency repairs should ease off in a few years, as should the repair costs. To evaluate the outcome, the number of breaks and the cost of emergency and planned operations will have to be documented and compared.

First, as concerns the number of breaks, the Service de l'eau must have access to an up-to-date history of the number of breaks to be able to show whether this figure is increasing or decreasing over time. During our audit, and during our work in 2012 on the implementation plan for secondary water and sewer system infrastructure, we requested, on several occasions, figures on breaks that occurred between 2006 and 2012. In so doing, we observed that the number of breaks attributed to each year kept changing. This situation can be explained by the fact that the DGSRE's Division du plan directeur is dependent on the boroughs' timing in terms of data production output. For example, if several water line breaks repaired between 2009 and 2011 are reported in 2012, the DGSRE's figures for the previous years would change accordingly. This situation also has an impact on how data are interpreted. For example, in July 2012, the DGSRE provided us with an overview covering the years 2006 through 2011 that showed that the number of breaks had decreased over this

period. According to the interpretation obtained from the head of the Division du plan directeur, the decline in the number of breaks was the result of the investments made in replacing and rehabilitating water lines. A subsequent overview covering the same period but dated February 13, 2014, instead shows that the number of breaks has increased over the years. The interpretation thus changes completely. We believe that the DGSRE needs to receive complete and up-to-date information in a timely manner to be able to interpret the data accurately and compare them with other pieces of information.

Second, in order to be in a position to reconcile the number of breaks with the repair costs, the DGSRE must have both sets of figures at its disposal. Accordingly, the direct costs for each water line repair operation carried out by the boroughs should cover:

- leak location;
- excavation;
- repair;
- signage while repairs are under way.

These costs should include labour, materials, equipment use and a percentage of administrative expenses.

During our audit, we noted that the DGSRE's Division du plan directeur did not have access to these data because the break reports entered into the corporate application did not prompt the user to provide them. The boroughs' work requests, work orders and water leak repair logs, however, do provide for the entry of data that can be used to assess direct costs (labour hours, materials and equipment). We ascertained during our audit that the Mercier–Hochelaga-Maisonneuve and Saint-Laurent boroughs were providing this information in the corresponding forms. However, only Mercier–Hochelaga-Maisonneuve borough indicated the associated unit costs, which it would then incorporate into its invoices to the DGSRE, pursuant to its partnership agreement. In the case of Saint-Laurent borough, the water leak repair log contains all the information required to determine direct costs, except the unit costs. Lastly, in the case of Le Plateau-Mont-Royal borough, the work request forms did not systematically integrate these data, which would have made it possible to assess the direct costs.

We feel that the tools provided to the boroughs should make it possible to convey the direct costs of the break repairs for each repair undertaken and that this information should be made available to the Division du plan directeur.

Moreover, to obtain a full evaluation of break repair costs, the corresponding indirect costs must also be factored in, including:

- property damage;
- disruption of local business;
- source of nuisance for the public;
- ancillary costs related to emergency services (firefighters and police).

These costs are clearly more difficult to calculate and require a more in-depth evaluation. According to the information obtained from the head of the DGSRE's Division du plan directeur, these costs are not currently assessed, although they can represent up to 80% of total water line repair expenditures. We would therefore argue that an evaluation of this nature is warranted.

In conclusion, we have noted that, even when water line breaks are entered into a corporate application, georeferenced in the databases so they can be posted in the SGIS and available for the purpose of producing RPs, they are inevitably all treated with the same level of importance. There is no difference between a break that entails considerable damage and costly repairs and a break of a lesser magnitude if the only indicator used is the break rate (breaks per kilometre per year). We therefore feel that the direct and indirect costs of the work on the water lines should be given the same consideration as the number of breaks in order to evaluate the true impact and prioritize the corresponding response.

4.2.B. Recommendation

We recommend that the Service de l'eau formally indicate its needs to the boroughs so they can generate detailed data on water line breaks (e.g., types of failures, types of repairs, causes). This will enable the Service de l'eau to conduct analyses and establish correlations to gain a better understanding of these breaks and prioritize its actions accordingly.

Business unit's response:

[TRANSLATION] Needs will be defined when the corporate application is updated (process currently under way). A new guide is also planned and will be used to train users. (Planned completion: December 2014)

4.2.C. Recommendation

We recommend that the Service de l'eau produce a definitive history of the number of water line break repairs in order to show how these figures have changed over a period of a few years and to measure the impact of the investments made in replacement and rehabilitation operations as well as the effect of implementing a leak detection process.

Business unit's response:

[TRANSLATION] The DGSRE is developing an infrastructure asset management report that will be submitted annually to the city manager starting in 2015. The decision has already been made to use this report to track water line breaks, since this is one of the key indicators of the condition of the drinking water system. (Planned completion: March 2015)

4.2.D. Recommendation

We recommend that the Service de l'eau undertake the necessary measures to ensure that the boroughs produce the data required to calculate the direct and indirect costs of the work carried out on water lines in order to evaluate the financial impact of water line break repairs and review, as appropriate, how certain actions are prioritized.

Business unit's response:

[TRANSLATION] The DGSRE has introduced a compilation tool to calculate the direct costs of work carried out on water lines. A sample of the boroughs has been established to ensure adequate representativeness.

A project is under way to assess the indirect costs of work performed on water and sewer systems. These operations may be planned (e.g., infrastructure renewal projects) or unplanned (e.g., emergency repairs). Indirect costs will be calculated in an effort to reflect the economic value of social and environmental damages sustained by residents. Eventually, this information will help justify the coordination of infrastructure work and outline the consequences of not taking action at the right place and the right time. (Planned completion: December 2015)

4.2.E. Recommendation

We recommend that the Service de l'eau send regular reports to city authorities on the number of water line breaks and the corresponding costs of emergency and planned repairs to show the consequences of the orientations undertaken with respect to preventive break detection, rehabilitation and replacement.

Business unit's response:

[TRANSLATION] The DGSRE is developing an infrastructure asset management report to be submitted annually to the city manager starting in 2015.

This report will track the number of water line breaks over time and evaluate the impacts of implementing a proactive leak detection system, especially in terms of reduced operating costs. (Planned completion: March 2015)

4.2.F. Recommendation

We recommend that the Direction de la gestion stratégique des réseaux d'eau carry out analyses and establish correlations between water line breaks and other relevant data, including data produced by the boroughs, to improve the overall level of knowledge of the causes of breaks in order to guide short- and long-term actions and to review, as necessary, the criteria to be used in the response plan's decision trees.

Business unit's response:

[TRANSLATION] The Division du plan directeur already prepares these kinds of analyses. (Already implemented)

Since 2010, two exhaustive analyses have been performed to find correlations between water line breaks in the drinking water system and the physical characteristics of the corresponding pipes (materials used, installation period, etc.).

Using these analyses, we were able to calculate the life expectancy of the various lines based on their current condition. This information will be updated periodically with new compiled data. (Planned completion: March 2015)

5. General Conclusion

The response plan (RP) is a planning tool that cost more than \$40 million to develop, not counting in-house expertise. It helps determine which water lines require priority treatment in terms of replacement and rehabilitation. The RP's sustainability is contingent on a continuous inflow of up-to-date data.

A formal update process for the primary water system has yet to be established. However, an update process for the secondary water system has been developed, although it is not being applied the way it was intended. Its use is not consistent from one borough to the next, as the "break report" in the corporate application is not completed by everyone. This report contains the elements required to update the RP. In addition, the boroughs do not all produce

complete data in a timely manner and are not all equally committed to generating quality information. The Direction de la gestion stratégique des réseaux d'eau (DGSRE) of the Service de l'eau, the unit responsible for producing the RP, has not established a formal validation process to control data quality. As a result, the databases do not contain all the information required to update the various systems that will be used for the next RPs.

Because of these shortcomings in the application of the data update process, the Service de l'eau cannot provide the Division de la géomatique of the Service des infrastructures, du transport et de l'environnement (SITE) with complete, up-to-date data on the number of water line breaks for subsequent transfer to the databases used by the Service des technologies de l'information (STI) to post these data in the spatial geographic information system (SGIS) and, ultimately, produce the RP. This reality is clearly an obstacle to the update process and, consequently, may compromise the status of certain water lines that should be earmarked for replacement or rehabilitation.

We believe that swift action must be taken to address these shortcomings before the next RP is produced in 2016. This is especially relevant given that the DGSRE is reportedly in the midst of designing a new break report that should help standardize the way data are shared by the boroughs and the Service de l'eau.

Furthermore, in an endeavour to reduce the number of water line breaks, the Service de l'eau needs to make every effort to obtain relevant data (e.g., types of breaks, types of repairs, causes, repair costs) so it can perform the appropriate analyses and establish the necessary correlations to improve the level of knowledge of the causes of water line breaks in an effort to guide its short- and long-term efforts.

Finally, the Service de l'eau, as the unit responsible for updating the databases to be used to develop the RP, must periodically send progress reports to city authorities on the number of water line breaks and repair costs in order to evaluate the impacts of the orientations undertaken with regard to the criteria used to establish priorities and the resulting sequence of work relating to preventive detection, rehabilitation and replacement. It is important to remember that the RP is a tool that should make it easier to establish response priorities. Changes must be made in the short term in order to leverage its contribution to the planning process and ultimately lessen the need for emergency work, cut costs and minimize public inconvenience.

6. Appendix

6.1. Statistics on the Number of Water Line Breaks in the Secondary Water System Repaired by the Boroughs in 2012

Table A – Georeferenced Water Line Breaks in the Secondary Water System, Breakdown by Borough – 2012

Borough	Number of breaks ^[a] (as of June 13, 2013)	Number of breaks ^[a] (as of February 13, 2014)
Unité Centre		
Le Plateau-Mont-Royal	119	38
Le Sud-Ouest	37	45
Rosemont–La Petite-Patrie	64	62
Ville-Marie	68	67
Unité Sud		
Côte-des-Neiges–Notre-Dame-de-Grâce	40	41
Lachine	28	29
LaSalle	26	26
Outremont	4	6
Verdun	23	24
Unité Est		
Anjou	16	16
Mercier–Hochelaga-Maisonneuve	86	93
Montréal-Nord	47	45
Rivière-des-Prairies–Pointe-aux-Trembles	43	44
Saint-Léonard	15	38
Unité Nord		
Ahuntsic-Cartierville	46	47
L'Île-Bizard–Sainte-Geneviève	11	11
Pierrefonds-Roxboro	71	78
Saint-Laurent	79	64
Villeray–Saint-Michel–Parc-Extension	77	77
Total	900	851

^[a] Statistics obtained from the DGSRE.