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A Socio-Economic Cost Assessment Regarding Damages to Underground Infrastructures

Executive Summary

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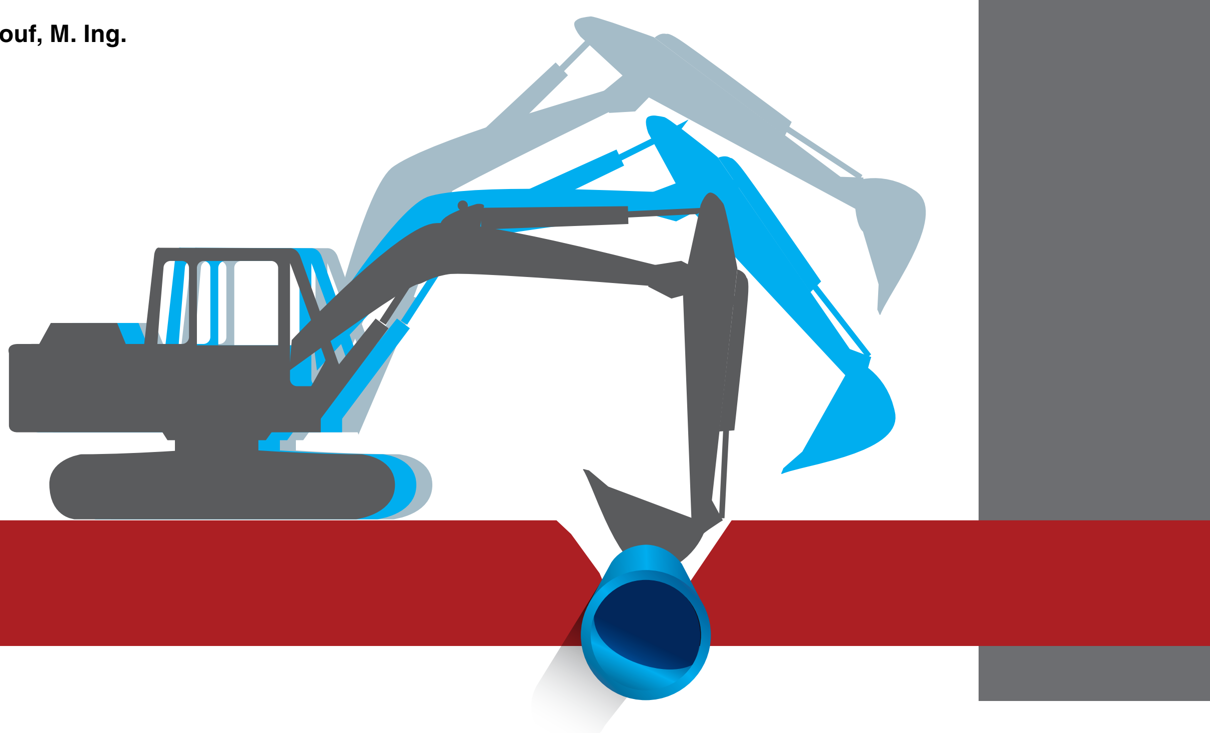

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Background and key issues

Underground lies a vast network of conduits and cables that delivers products and services to today's society. These underground infrastructures include telecommunication and electrical cables, gas conduits, sewers, water lines, drainage systems, oil pipelines, etc. The increasing number of networks, along with their shallow burial, translates into contractors regularly striking them while doing repair or rehabilitation work of all kinds.

Alarming Statistics Concerning Damages

There is an average of 5 damages per day to underground infrastructures in Québec. In 37% of cases, services needed for locating underground infrastructures were not used (locate requests made to Info-Excavation), 35% of cases needed the intervention of the municipalities' emergency services, 89% of damages were caused by backhoe operators and 83% resulted in service interruptions (APISQ 2012). More alarmingly still is that the numbers are certainly higher than those documented. Indeed, reporting is made on a voluntary basis and many underground infrastructure owners do not participate in the data collecting program put forth by the Alliance pour la Protection des Infrastructures Souterraines du Québec (APISQ). In addition, the number of damages to underground infrastructures went up by 6% in 2012, after a three year drop.

Damages Endanger People and Workers

People, more specifically workers are endangered since they are exposed to serious injuries and sometime potentially deadly situations. In Canada, there is currently no database on injured or killed workers related to damages to underground infrastructures. The data is however available. We know for a fact that no deaths have been reported in Québec following damages to underground infrastructures. Yet many accidents have taken place. In March 2012, a worker nearly drowned following damages done to a primary water line in Montréal's Ville-Marie borough. However, there have been fatal accidents in other provinces.

Since 2008. there have been 7 fatal accidents in Ontario. Since 2008, there have been in British Columbia 2 fatal accidents and 6 seriously injured workers due to damaged underground infrastructures following excavation work (with an average of 1,600 infrastructures struck annually).

In the United-States, the US Department of Transportation, section Pipeline and Hazardous Materials Safety Administration compile each year serious accidents for each type of pipeline operators. It should be noted that American laws are more strict. It is mandatory that locate requests be made prior to excavation work and owners/operators of underground infrastructures must be affiliated with one call centres. Offenders are liable to steep fines. Today, all American states have their own legislation that is oriented toward the protection of underground infrastructures and each state has its own one call centre. This initiative significantly reduced (by 70%) the number of damages done to buried utilities. American statistics are quite alarming: 16 injured and 2 fatal accidents in 2011 due to work-related damages to underground infrastructures.

Purpose of research:
identify and quantify the total damage related costs to underground infrastructures in Quebec

Impacts on underground infrastructures can be distinguished into two types of costs:

Direct costs

are related to repairing the damage (replacing damaged materials, mobilizing technicians to repair the damage).

Direct Costs are related to the following damages:

- Costs of replacement materials used
- Costs of materials used
- Labour costs
- Administrative costs needed to rehabilitate the damaged infrastructures

Indirect costs

are those that arise from the damage. These costs correspond to the economic assessment of all disturbances that have a more or less important link with the damages sustained. They are varied and can cover a wide range of domains. They can represent a service disruption, affect the workers' health and safety, cause traffic disturbances, mobilize emergency services as well as affect the health and safety of emergency workers (i.e.: fire fighters) or can represent the administrative costs related to the procedures that arise from such accidents. In addition we must add the costs related to the environmental impacts (noise, vibrations and all forms of pollution) as well as those related to the economic impacts (loss of revenue, absenteeism and lateness for work, etc.). In most cases, these additional costs are borne by society.

The overall costs represent the total damage related costs to underground infrastructures. ***If a network's repair cost is relatively easy to identify and allocate to a given damage, the same cannot be said of indirect costs that are difficult to quantify and are rarely taken into account when making decisions related to damage prevention.***

The research's general objective is to present a detailed study of damage related indirect costs to underground infrastructures that could be used for damage prevention and as an incentive for best practices. By providing a complete list of socio-economic costs and a realistic damage related costing, this essential step will help convince contractors of the importance of damage prevention as well as help reduce the total damage related costs for everyone (companies, population, municipalities, emergency services, etc.).

This project is even more relevant since urban networks are more and more buried, be it for aesthetic reasons (effort to repossess the landscape) or for security reasons (risk reduction due to climate incidents, risk elimination associated to the presence of vegetation in urban environments). In this respect, the importance of improving underground network management takes on an even greater dimension.

To carry out the research project we have set three specific objectives for which we have responded:

1. ***Develop a typology for direct and indirect costs that will help define the importance and great diversity of such costs. A formula was allocated to each cost to help in its estimation.***
2. ***Quantify total costs for four types of damages to underground infrastructures in Québec and estimate a direct-indirect costs ratio.***
3. ***Analyze the results yielded so as to capture the full scale of the actual damage related indirect costs to underground infrastructures in Québec.***

Result No 1:
A wide array of indirect costs that are most often forgotten

A literature review helped us define the different types of damage related indirect costs to underground infrastructures. The goal was also to associate each cost item with an estimation method.

The direct costs represent the tip of the iceberg, which as you can see is quite small compared to what lies beneath. In fact, the list of indirect costs is often longer and many of these costs are often forgotten. These damages can also trigger indirect costs such as:

Service disruption following damages to infrastructures

A service disruption of an electrical network for one client, for example, may sometimes represent an hourly cost of thousands of dollars. These costs may increase rapidly when it touches businesses or institutions.

Intervention of emergency services

When a gas conduit is damaged, firefighters are required on-site. Costs related to mobilizing emergency services (trucks and firefighters) are significant and may be accompanied by opportunity costs that are just as important if, for example, firefighters being on-site may prevent them from responding within a normal delay to a call that requires immediate assistance (i.e. cardiac arrest).

Evacuating residents and businesses in certain cases

When their security is at risk.

Risk for the workers' health and life

When an underground infrastructure is damaged, its employees are exposed to additional risks during repair activities: risk related to gas leaks and risks related to work overlapping between employees of different networks, etc.

Loss of product

As of today, no one knows precisely in Québec what is the actual cost to businesses, municipalities and society in general when an underground infrastructure is damaged. We need to be able to measure more precisely the extent of such costs. It is also important to mention that many players bear the brunt of those costs not only the one responsible for the damage.

Environmental impacts

Among these environmental impacts we find noise and vibrations which impact both the productivity of employees that are victims of such disturbances as well as the loss in market value of buildings during major repair work. With regards to the pollution emitted it can be displayed in two different forms. The first is fine particulates such as greenhouse gas emissions and other emissions made by the over-consumption of energy during traffic congestions. The second is dust production made during repair work on damaged underground infrastructures.

Economic impacts on businesses and firms

A decrease in turnover due to service interruptions (payment methods/Internet, etc.) or lateness or absenteeism (due to traffic congestion, etc.) have an economic impact on businesses and firms.

Work delays

The time lost stopping the leak, repairing a conduit, etc., often causes worksite delays, which in turn may cause late penalty fees for contractors (who are responsible for the damage or who must come after them during a construction phase) or cost overruns due to overtime work or the extra personnel hired in order to address such delays. Furthermore, the worksite may be closed for investigation when there are injuries or for legal reasons which in turn entails costs.

Administrative and legal costs

During a flood, for example, the costs will be recorded under administrative costs so as to deal with complaints and claims. These costs may be supported either by municipalities or by insurance.

Tarnished company image for owners of underground infrastructures

This element is hard to quantify. However, when an underground infrastructure is damaged, the network's vehicles marked with the company's name are often on-site and may cause traffic disturbances. Being visible, they may have a negative impact on the company's reputation. Furthermore, service interruptions may also tarnish the company's image.

Soil disturbances and surrounding infrastructures

Damages to a water pipe, for example, can sometimes cause excess pressure on the network which in turn may translate into breaks in the water main.

Traffic disturbances

Here the costs fall under many categories: time loss because of traffic congestions, detours, over-consumption from both previously mentioned effects as well as the increase in maintenance costs. It should also be noted that changes in driving behaviour due to traffic congestion may cause traffic accidents.

Used formula to estimate daily costs of time loss due to traffic congestions

Extra time needed to cover the distance (t)		(t)
	×	
Number of vehicles per day		(veh/d)
	×	
Passengers' hourly rate for the relevant area ($/t)		($/t)
	÷	
Number of hours worked per year in Québec		(t/year)
	=	
TOTAL		**($/d)**

Result No 2:
Estimates of costs related to actual circumstances indicate the true level of indirect costs

To illustrate the evaluation methods regarding the proposed costs and to evaluate the ratio of indirect to direct costs, 4 case studies were used. These case studies are meant to represent damages to underground infrastructures in Québec. They have been chosen to illustrate different types of infrastructures that can be damaged (telecommunications, gas and water), their size as well as different cost elements that were presented in the literature review. The case studies serve to highlight the importance of damage related indirect costs. Quite often, indirect costs (IC) represent 80% or more of total costs, which is 4 times more than direct costs (DC).

Case study (1): a damaged gas conduit in the downtown area of a large agglomeration in Quebec

The first case study represents a **damage to a main gas conduit in the downtown area of a large agglomeration (Montréal).** This type of damage can be found frequently in this city and it requires the intervention of the fire department. According to the statistics of the fire department, there is an average of 400 damaged gas conduits in Montréal each year. The presence of **41 firefighters and 11 emergency response vehicles was needed for over 1h30 for a damaged gas conduit. The estimated cost was over $12,000.** It is important to state that all gas leaks in Montréal automatically trigger the deployment of the fire department. Furthermore, even if it is a gas conduit that has been damaged, it is increasingly common, for safety reasons, to order a **power outage in the perimeter surrounding the leak.** In this case, **1720 clients were touched by this power outage** which lasted over 1h30. Even if no congestion was reported, **results show that more than 99% of costs due to this damage were in fact indirect costs.** Direct costs consisted of labour costs as well as the material and equipment needed to repair the gas conduit.

Photos: CIRANO and Gaz Métro

Case study (2): a damaged telecommunications network of a large agglomeration in quebec

The second case study represents a **damaged telecommunications underground infrastructure of a large agglomeration (Montréal)** on the corner of Jean-Talon and Côte-des-Neiges. Repair work lasted several days causing important traffic congestions. Since repair work was **completed in 23 days** and it was located on a **major artery of Montréal,** this case study helped us uncover the costs associated with traffic congestion when a damaged underground infrastructure was repaired. If we take into account the costs related to time loss, over-consumption, pollution and the increase in the maintenance of vehicles (about 20,000 vehicles use this crossroad on a daily basis) we arrive at a **total indirect cost of more than $170,000 related solely on traffic congestions.** This case study not only helped establish the proportions between the different costs related to congestion, but also those related to detours. Furthermore, we must take into account other costs that are hard to quantify such as the loss of reputation for the telecommunications company. In fact, during the damage and the 23 day repair that followed, many company marked vehicles were seen on-site and caused traffic congestions. By sounding motorists, pedestrians and merchants in the area, we realized very quickly that the blame was put on the visible player, in this case the telecommunications company, which was on-site repairing the damaged infrastructure, even if the damage was caused by a third party to begin with. In this case, the **total costs can be divided into direct costs, which represent 19% and indirect costs which represent 81% of the total costs.**

Photos: CIRANO and Bell

Result No 2:
Estimates of costs related to actual circumstances indicate the true level of indirect costs

Two case studies that reflect damages to a water line

Case study (3): minor damages to a water pipe of an average agglomeration in Quebec

The third case study represents a **water line breakage in a residential sector of a medium-sized city (Gatineau).** This case study allowed us to assess the indirect costs of smaller damages to underground infrastructures. The costs are related to the issuance of a boil water advisory (laboratory tests, costs of communications to citizens, etc.), to traffic congestions and detours and the loss of drinking water. Even if indirect costs (estimated at approximately $3,300) represent only 30% of total costs related to the damage, **this percentage takes on a new meaning when we consider the recurrence of this type of damage. In Gatineau, for example, the city deplores every year 200 breakdowns of water lines.** Even if the indirect costs of these minor damages only account for a small portion of the total costs, it is still important to factor them in. It's the recurrence of this type of damage that makes it to this day a real concern, as much in terms of costs, as in terms of security level and comfort of the citizens living in the affected areas.

Case study (4): major damages to a water pipe of a city in Quebec

The last case study represents a **large water pipe breakage in a city of Québec.** This study allowed us to assess the total costs of large scale damages with major impacts. Owing to its importance, this study also allowed us to highlight the impact of the domino effect. In addition to the direct and indirect costs mentioned above, we have also observed the emergence of additional indirect costs due to the secondary effects of the main damage.

In such instances, closing the main conduit caused an excess pressure on the adjacent neighbourhood's network which, due to the age and fragility of its water pipes, caused minor damages on secondary conduits.

The direct costs related to the initial damage account for 17% of total costs which were estimated at $1,300,000. By adding the additional secondary damages that are linked to the first major damage, the direct costs account for just 13% of total costs.

These case studies have revealed that depending on the type and importance of damage and its location, the ratio between direct and indirect costs vary, and that in most cases, indirect costs are far greater than direct costs.

Result No 3: important damage related indirect costs to underground infrastructures in Quebec: A minimum of 74.5 million dollars for 2012

To get a better understanding of the situation in Québec, we have estimated the total annual damage related indirect costs to underground infrastructures which have occurred in Québec in 2012. To achieve this, we used the information from a database in which different actors can register online the information regarding various events related to underground infrastructures (damages, near damages or downtime). The database called DIRT (Damage Information Reporting Tool) or ORDI in French (Outil de rapport sur les dommages aux infrastructures) was created in 2003 for the Common Ground Alliance (CGA). The Québec information contained in the database have been grouped and analyzed according to methods of calculation developed in this project and to results obtained in the case studies. Damages can be grouped into 4 categories depending on the type of damaged infrastructure (electric, gas, telecommunications or other (often water lines)).

We have estimated that in 2012, damages to underground infrastructures in Québec **amounted to 74.5 million dollars of indirect costs.** It is important to note that this figure is very conservative and could be quite higher. First, the estimated amount is based on damages recorded on a voluntary basis in the DIRT database. This only gives us a partial picture of what goes on in reality. It is also important to add that the estimated indirect costs do not take into account certain aspects such as the decrease in quality of life as well as the loss of human life (no loss of human life was reported following damages to underground infrastructures). Furthermore, we did not have any data regarding the presence of sensitive sites near the damaged infrastructures (hospitals, airports, factories, etc.). The presence of such sensitive sites near a damaged infrastructure could only increase the effects of the damage and would necessarily entail higher indirect costs.

Taking into account the limitations set forth, it is possible that in 2012, the 74.5 million dollars associated to the total indirect costs of damaged underground infrastructures in Québec could be readjusted to hundreds of millions of dollars. This economic estimation combined to the health and safety aspect reflects the importance of prevention. It could very well translate into systematic locate requests to Info-Excavation before excavating or by the use of best excavation practices.

Furthermore, statistics speak for themselves. The damage percentage in 2012 was estimated at 0.5% when there was a locate request made to Info-Excavation. Obviously the key here is prevention! Moreover, 449 damages happened when no locate requests were made to Info-Excavation, which means (if we apply the above mentioned percentage) that nearly one third of damages in 2012 could have been avoided if a locate request had been made to Info-Excavation. These elements only serve to underline the importance of prevention.

Conclusion
Importance of damage prevention

The assessment of actual costs related to damaged underground infrastructures in Québec can:

- underline the importance of damage prevention and help justify certain investments toward damage prevention and best practices training programs for building and repair contractors;
- help municipalities and other stakeholders allocate resources targeted at damage prevention and maintenance of high-quality networks;
- assess the relevance of developing partnerships (i.e. insurance or other emergency stakeholders).
- help municipalities and other stakeholders of this sector (fire department, Info-Excavation, owners of underground infrastructures, building and repair contractors, etc.) to better assess a project's actual risks and identify the least expensive solution based on the lowest generalized costs, be it for new constructions or as preventive measures, etc.

Recommendations

Taking into account the findings and results of our research, we are able to make recommendations depending on the actors that intervene when an infrastructure is damaged.

For excavation companies or individuals doing excavation work:

1. Excavation companies should follow damage prevention training sessions and know the guides for best excavation practices available.
2. Locate requests to Info-Excavation should be made mandatory in Québec.

For owners of underground infrastructures:

3. Registering and declaring to Info-Excavation the location of their network should be made mandatory to all owners of underground infrastructures.
4. Owners of underground infrastructures should improve the precision of their data pertaining to the location of their underground network and pursue their efforts to identify the existing networks

For clients:

5. Locate requests to Info-Excavation should be mandatory for clients before writing the excavation tender so that initial estimates are as precise as possible and plans and technical specifications are more detailed in terms of excavation constraints for bidding companies.
6. Clients should include in their excavation tender a clause that requires the winning tender to contact Info-Excavation before starting any excavation work.

For municipalities:

7. With regards to planning and maintaining their underground infrastructures, municipalities should use the results of this study in order to integrate them in their decision-making process.

We would like to thank the following contributors that have provided the data for our study: Info Excavation, the Alliance pour la protection des infrastructures souterraines du Québec, the city of Gatineau, Gaz Métro, Bell, Hydro-Québec, Montréal's Fire Department and Montréal's Police Department. We would like also to thank MITACS.

Web event CIRANO on the topic:
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Reference

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