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QUALITY OF ROAD INFRASTRUCTURE: *MANAGING ROAD ASSETS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE ADAPTATION*

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ABSTRACT

In an open economy such as that of Québec, where more than two-thirds of economic exchanges take place at the continental level, and largely by road, the availability of quality transportation systems takes on a fundamental importance in terms of economic development. Transportation infrastructures have suffered from two decades of under-investment, and they are exposed to ever-increasing traffic loads. In light of this, the government launched the *Québec Infrastructures Plan* (QIP) in 2007, with a 5-year budget of $38B (CAD) and a goal of renewing public infrastructures over a 15-year horizon.

Against this backdrop, the Ministère des Transports du Québec (MTQ) developed its *Plan de redressement du réseau routier* (highway system renewal plan), which has a 5-year budget of $13.3B. The Plan is centred around intervention strategies that are adapted to the conditions of the road network, with the objective of ensuring that the efficiency and quality of road infrastructures in Québec is maintained. After the first 4 years, these strategies are proving to be effective – the condition of roads has improved by more than 6%, and the condition of structures has improved by close to 9%.

In parallel with this, the implementation of the *Québec Public Transit Policy*, with a 5-year budget of $2.0B, resulted in an increase in ridership of 6% over 2 years (2006 to 2008), thanks to the improvement in supply related to a greater than 7% growth of the vehicle fleet, among other things. These public transit actions, along with those related to asset maintenance, are among the objectives of the MTQ's *Sustainable Development Strategy 2009-2013*.

In terms of the fight against climate change, Québec's commitment to achieving a target of reducing greenhouse gas emissions to 20% below 1990 levels by 2020, which was announced a few weeks before the Copenhagen Summit, places it among the world leaders in this area.

The issues involved in adapting to climate change also place significant demands on the MTQ, which must now deal with their impacts on transportation infrastructures. A number of research projects are currently underway, with a view to determining the most effective adaptation methods for dealing with the effects that are already being felt and those that are anticipated, especially in the Nord-du-Québec region (north of the 55th parallel).

1. THE IMPORTANCE OF TRANSPORTATION IN QUÉBEC

Transportation networks are a key link in the economic and social development of Québec. In the context of an open economy, it is essential that businesses have access to efficient and effective transportation systems, because transportation costs are a determining factor with respect to their competitive position. Shippers now face more stringent requirements with respect to the reliability, speed, and flexibility of transportation services. They rely on efficient supply chains to reduce costs, and performance becomes the key criterion, regardless of the mode or modes of transport used.

Within the territory of Québec, jurisdiction over the various modes of transport differs among the federal-provincial-municipal levels of government depending on whether the jurisdiction relates to infrastructures, activities, traffic or safety. With respect to roads, the government of Québec has exclusive jurisdiction over infrastructures and the management of vehicle traffic. On the other hand, Québec shares jurisdiction for actual transportation activities with the government of Canada.

The Québec economy benefits from its proximity to the United States, which stands as its main economic partner, accounting for more than 36% of the value of trade (in 2006). However, the US share of Québec's foreign trade is declining steadily. This situation reflects the diversification of import-export markets, with the rest of the world accounting for close to 33% of trade. Trade flowing between Québec and the other Canadian provinces represents slightly in excess of 31% of the total value of Québec's foreign trade. More than 61% of this trade is with the province of Ontario.

Québec's transportation infrastructures constitute a common heritage that represents a strategic asset. On their own, transportation infrastructures under the responsibility of the MTQ have a replacement value that was estimated at more than $80B in 2006. The investments made in the transport sector generate considerable economic activity, and have a significant impact on employment. In 2008, the transport industry employed somewhere in excess of 300,000 individuals, which represents 8.9% of total employment in Québec. The industry involving the transportation of persons and goods (including warehousing) accounted for 4.2% of economic activity in Québec in 2008 (GDP).

The most widely known effects of the Québec government's investments in road infrastructures are the effects that they have on the labour force. In fact, public investment in transport generates significant spin-off benefits in terms of employment, with each investment of $1 million leading to the creation and retention of a variable number of direct and indirect jobs, depending on the nature of the works (maintenance versus construction). It is estimated that the investments planned for 2010-2011, which amount to almost $4.2B, will lead to the creation or retention of more than 56,300 jobs.

The highway system, which falls under the jurisdiction of the MTQ, comprises 5,150 structures and more than 30,000 km of roads, which are classified hierarchically according to their function: autoroutes, national highways, regional highways, collector roads, and resource access roads. The strategic support network for foreign trade (RSSCE – *réseau stratégique en soutien au commerce extérieur*), which is part of the highway system, comprises mainly autoroutes and national highways (7,724 km) It constitutes the basic framework for meeting the requirements of an international market economy, making it possible to access markets and interconnecting the various regions of Québec. The RSSCE represents less than 26% of the length of the highway system, but serves more than 87% of the population and more than 91% of total jobs in the province.

Its purpose is to support the efforts of the various economic agents in Québec with respect to foreign markets by identifying the main transportation infrastructures that support Québec's foreign trade.

Table 1 – Main characteristics of the Québec road network

Type	Length (km)	Function	Responsibility
Highway system (including the RSSCE)	30,372 (7,724)	Provides access to major business hubs	Ministère des Transports du Québec
Local road network	102,000	Provides access to businesses and residences in the cities and towns and to rural populations	Municipalities
State-owned road network	186,000	Provides access to natural resources	Ministère des Ressources naturelles et de la Faune du Québec
	534	Parks, autoroutes, and bridges	Government of Canada
	3,300	Hydroelectric installations	Hydro Québec
Total (approximate)	320,000		

2. DURABILITY OF INFRASTRUCTURES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

2.1 The *Québec Infrastructures Plan: Foundations for Success*

Despite the growth in investment budgets dedicated to the maintenance of assets since the early 2000s, the government has identified a need to increase the amounts allocated to compensating for more than twenty years of under-financing. As a result, the government announced the *Québec Infrastructures Plan: Foundations for Success* (QIP) (Québec, 2007) in the fall of 2007. The objective of this plan is to make up the cumulative maintenance deficit over a 15-year period, and to ensure the durability of all public infrastructures in Québec. The principles underlying the implementation of this plan are as follows:

- To pass on quality infrastructures to the Quebecers of tomorrow (intergenerational equity);
- To provide modern, effective infrastructures of good quality, which is a fundamental requirement for dynamic and harmonious economic development;
- To ensure the safety and improve the quality of life of the public who use public infrastructures every day.

The plan calls for $30B in funding for the first five-years, with additional investments of $7.6B for the completion of projects that are already underway. The government's initial intention was to devote 80% of the funds to asset maintenance and to eliminating the maintenance deficit of past years, and 20% to infrastructure improvement and replacement.

Therefore, the road network ($13.3B) and public transit ($2B) accounted for more than 40% of the investment budgets allocated for 2007-2012, with the objective of providing Québec with safe, high-quality transportation infrastructures. It is worth noting that the road

network budget includes $100M/year in funding for the restoration of 4,270 bridges located on networks belonging to municipalities with a population below 100,000, which the MTQ assumed responsibility for in 2008.

The government of Québec also provided itself with a legal framework by adopting the *"Act to promote the Maintenance and renewal of public infrastructures"* (Québec, 2007b), which creates an obligation for government departments and agencies to maintain and renew the infrastructures under their jurisdiction according to the established guidelines. These organizations will be required to eliminate the cumulative maintenance deficit (CMD) over a 15-year period, at a rate of 6% per year. Another provision of the Act requires the government to adopt an annual investment plan, and to submit a report on the use of the funds to the Members of the National Assembly each year.

Completion of the first stage in the implementation of the QIP required that the departments and agencies evaluate their CMD on April 1, 2008 and develop a management framework for asset maintenance investments (*CGIMA – Cadre de gestion des investissements en maintien d'actif*), which is designed to facilitate annual reporting. The MTQ already had asset management systems in place, and was able to evaluate its CMD and relate it directly to the long-term intervention strategies for sustainable restoration of the condition of road structures. The CMD for the highway system was estimated at close to $8B ($3B for roads and $5B for structures).

Table 2 presents the planned QIP investments for the 2009-2014 period. The current allocation is 71% for asset maintenance, elimination of the CMD, and road network improvements, and 29% for adaptation and completion of the network (development).

Table 2 – Five-year investment plan for the highway system

	2009-2010	**2010-2011**	**2011-2012**	**2013-2014**	**2013-2014**	**2009-2014**
Asset maintenance	$1,520	$1,796	$1,848	$1,684	$1,727	**$8,573**
Improvements	$424	$511	$511	$719	$727	**$2,896**
Development	$1,138	$1,161	$1,013	$778	$698	**$4,787**
Total	**$3,083**	**$3,468**	**$3,372**	**$3,182**	**$3,152**	**$16,256**

The MTQ's interventions in the area of public transit take the form of funding programs for public transit authorities. The planned budgets (Table 3) are allocated as follows: 70% for maintenance and elimination of the CMD, 12% for improvements and replacement (this category does not apply to the road network), and 18% for development.

Table 3 – Five-year investment plan for public transit

	2009-2010	**2010-2011**	**2011-2012**	**2013-2014**	**2013-2014**	**2009-2014**
Asset maintenance	$520	$483	$363	$288	$256	**$1,911**
Improvements/Replacement	$114	$80	$76	$64	$1	**$335**
Development	$205	$171	$149	$1	–	**$4526**
Total	**$839**	**$735**	**$588**	**$353**	**$257**	**$2.772**

2.2 Highway system renewal plan

In order to solidify the government's commitment to the renewal of public infrastructures, the MTQ developed the *Plan de redressement du réseau routier* (highway system renewal plan), with the goal of ensuring that the roads that make up the highway system in Québec are efficient and safe for users, and that the investment costs related to maintenance and rehabilitation are optimized.

The government of Québec established quality targets to be achieved between 2007 and 2023, namely an increase in the proportion of the number of kilometres of roads in good condition, from 63% to 83%, and an increase in the proportion of the number of structures in good condition, from 53% to 80%. Figure 1 illustrates these targets, which differ among the roads comprising the highway system, depending on whether or not they are part of the RSSCE.

The Québec road network has been affected by normal aging phenomena, which represent the combined effect of heavy traffic and climate. In this context, it was not only necessary to increase the budgets, but also to adjust the intervention strategies, because it has been proven that strategy is just as important in terms of accelerating the renewal process as the investment budget. In light of this, the MTQ adopted new intervention strategies for roads, structures, culverts, and several other components of its road assets.

In addition, the five-year intervention planning process includes a step that allows MTQ specialists to carry out a pre-evaluation of the impacts of the proposed annual program on the results in terms of the condition to be expected. If required, a feedback loop involving MTQ territorial managers is added to the planning process in order to adjust and optimize the results in accordance with the planned budgets and in compliance with the intervention strategy adopted.

This section of the report summarizes the new methods, and demonstrates the effectiveness of these strategies by presenting the results that have been achieved.

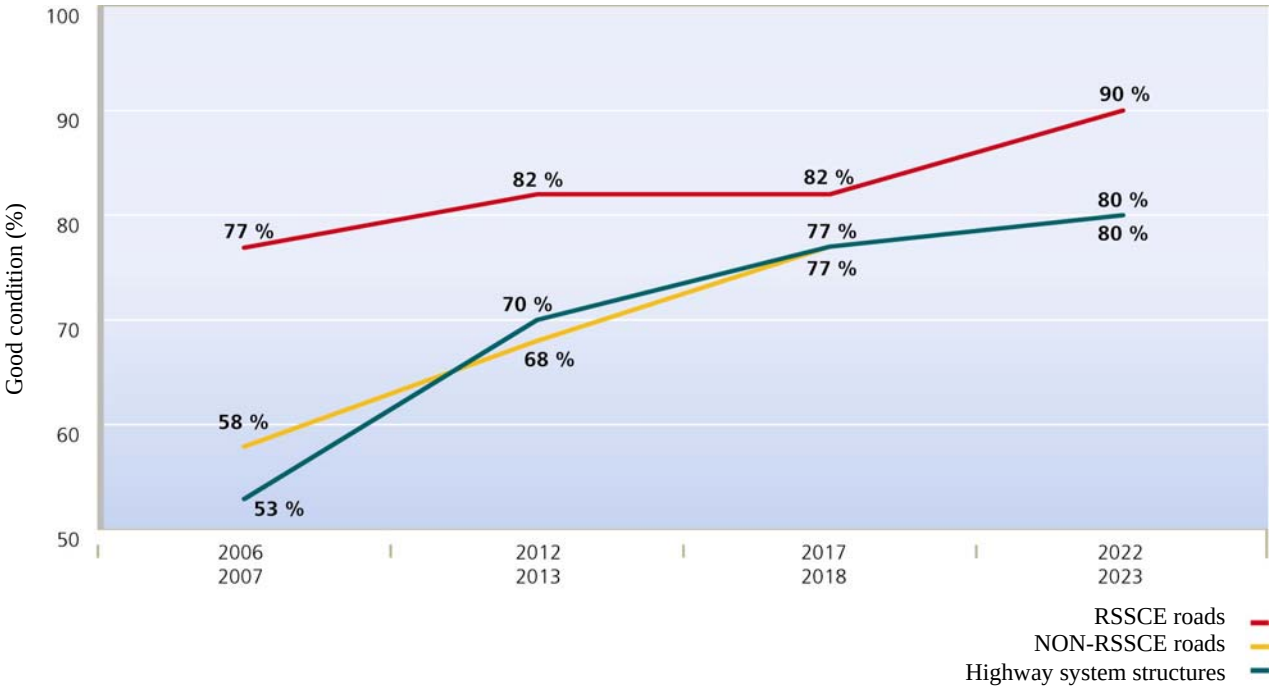

Figure 1 – Targets for the highway system renewal plan, 2007-2023

2.2.1 Asset maintenance strategy

2.2.1.1 Pavements

Since the late 1990s, the MTQ has developed a number of indicators that make it possible to measure changes in road condition, namely annual measurements of ride quality, rutting, and cracking on 50% of the highway system. This means that the entire network is covered over a two-year period. Damage progression models are applied to the data collected the previous year in order to prepare a complete and realistic annual report on the condition of roads.

The thresholds used to define the condition of a road can be found in the document entitled *Bilan de l'état des chaussées du réseau routier supérieur québécois 2009* (2009 report on road conditions within the Québec highway system) (Québec 2010). These thresholds vary according to the functional class of the road. It is worth noting that the evaluation activities related to the highway system that are used in drafting this annual report are strictly governed by a quality assurance program (ISO 9001: 2008).

These data pertaining to road conditions have been used to develop the intervention strategy aimed at optimizing road network investments for the 2006-2012 period. This strategy is based on the latest principles of good road management, and focuses on five complementary components (Table 4). The implementation of the strategy requires a sustained effort to alter traditional approaches by limiting palliative or temporary interventions to segments that are in very poor condition, by emphasizing preventive maintenance for the many segments that are in good condition, and by prioritizing interventions that have advantageous investment/performance ratios.

Table 4 – Budget allocation by type of pavement intervention

Types of interventions	**Strategy 2006 to 2008**	**Strategy 2009 and 2010**	**Strategy 2011 and 2012**
Preventive	5%	5%	5%
Palliative	20%	10%	5%
Selected based on cost/benefit related to ride quality	25%	30%	35%
Selected based on cost/benefit related to rutting	25%	30%	30%
Other considerations (safety, capacity, constraints, local agreement)	25%	25%	25%

2.2.1.2 Structures

The Québec highway system, which is managed by the MTQ, includes more than 5,150 engineering structures that are a minimum of 4.5 metres in length, representing a total surface area in excess of 5 million square metres. More than 75% of this asset base was constructed between 1960 and 1980. Rehabilitation work for a structure is generally required 30 years after construction, and therefore, the MTQ has adopted a strategy aimed at determining the best time for carrying out interventions, based on the life cycle of the structures. The challenge is to invest in the right structures at the right time, with the right technology to maintain the assets in good condition.

The intervention strategy that was developed for highway system structures seeks to allocate investments in such a way as to achieve a long-term effect on the evolution of the quality of the network. It is divided into four components:

- Regular structures: The largest portion of the investments (approximately 60%) is allocated to this component, which involves four criteria that have been identified for determining intervention priorities: safety, maintaining structures in good condition, loss of functionality (related to damage to load-bearing components), and additional functionalities. However, the significant requirements related to priorities 1 and 2 have swallowed up the entire budget allocated to date. On the other hand, many of these interventions have simultaneously met the requirements of priorities 3 and 4.
- Major works on large structures: These structures are treated separately. One-third of the budgets are allocated to them.
- A specific amount is also set aside for specific types of structures, such as signalization structures, light standards, and work on ramps.
- Non-recurring preventive maintenance: This component groups together small-scale interventions that prolong the life cycle of structures in good condition.

Based on this budget allocation, repair interventions are planned according to the condition and functionality of a structure. The status of a structure is considered to be “Requires repair” with respect to its condition when work must be carried out within the next five years in order to correct defects found on its main components during inspections (ISO 9001: 2008). The status of a structure is considered to be “Requires repair” with respect to its functionality when its physical characteristics (load-bearing capacity, lane width, clearance, etc.) are inadequate to meet the needs of road users. Finally, it is important to note that a structure can be considered to be “Requires repair” with respect to both condition and functionality at the same time.

2.2.1.3 Culverts

In 2003, the MTQ implemented a program for managing its culvert assets, which comprise close to 56,000 small engineering structures with an opening of less than 3 metres that are buried under roads. With a view to adopting an intervention strategy, one of the tools that the MTQ developed was a culvert condition index based on scores from 0 to 100, grouped together into 5 classes, with a score of 100 corresponding to a structure in perfect condition.

An initial intervention strategy based on this condition index was adopted in 2007, and carried over until 2013-2014. Priority was given to culverts within the RSSCE (11,385 culverts) and those located within the remainder of the highway system (72%) with an opening between 1.5 and 3 metres (3,298 culverts). These two categories represent 25.5% of all culverts managed by the MTQ.

An intervention priority index was then calculated, taking into account two main risk factors: one deriving from the observed condition of the culvert; and the other reflecting the expected socio-economic impact if the structure should fail.

2.2.2 Condition results

2.2.2.1 Pavements

Figure 2 shows the progress made by the MTQ in applying its intervention strategy for roads within the highway system, depending on whether or not they are part of the

RSSCE. It reveals an ongoing increase in the proportion of roads in good condition since 2007.

An analysis of Figure 3 reveals that the proportion of surface rehabilitation works has declined and that of temporary and preventive works has increased. The relative weighting of deep reconstruction and rehabilitation works has not changed significantly.

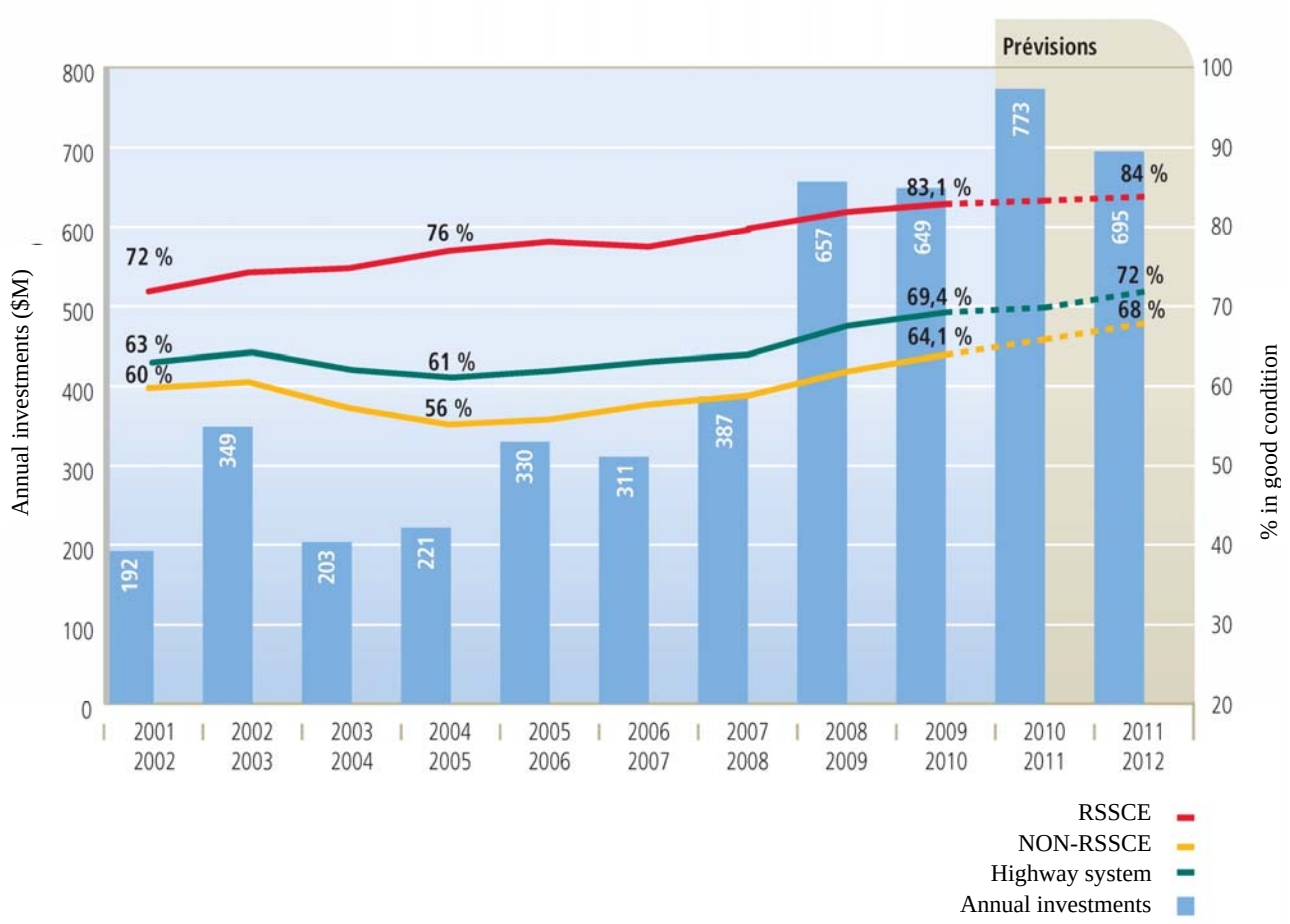

Figure 2 – Change in the condition of roads and annual investments

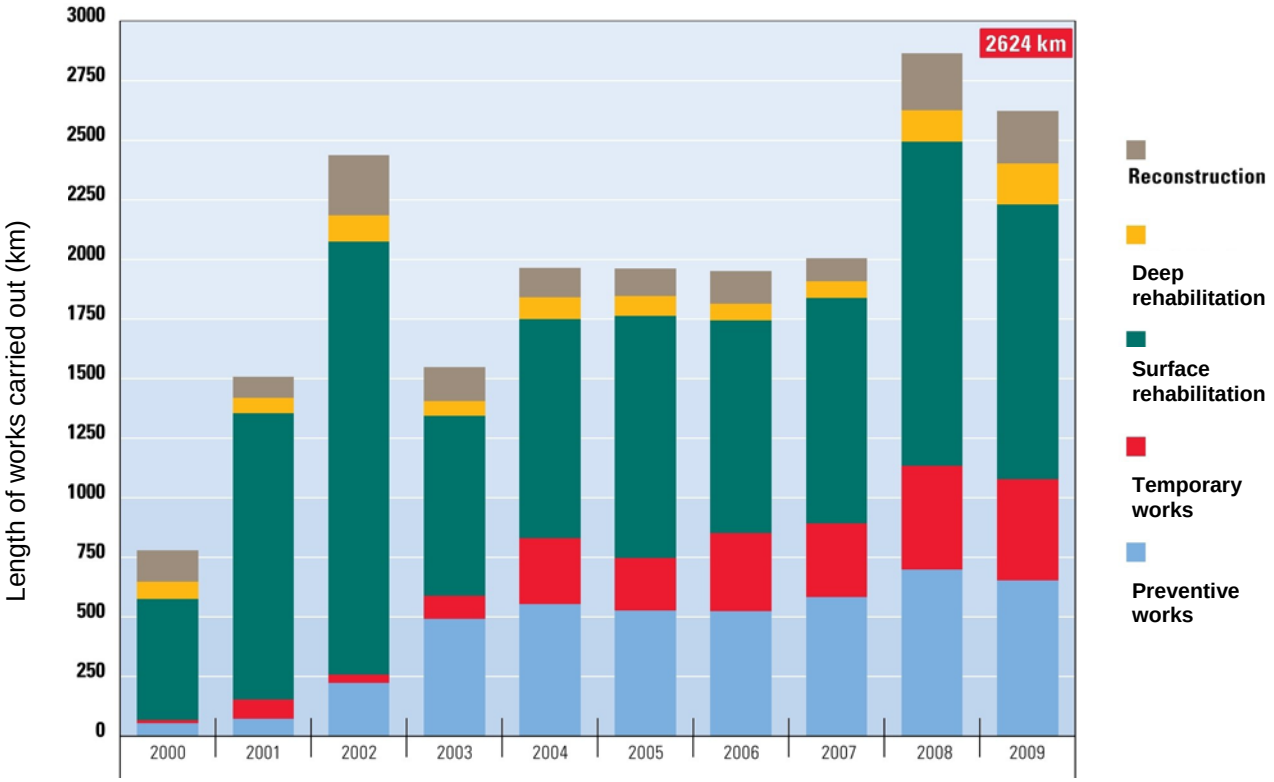

Figure 3 – Length of works carried out on roads by type

2.2.2.2 Structures

As shown in Figure 4, the condition of structures has improved steadily since the renewal plan went into effect in 2007. This constitutes a reversal of the trend that was observed going back to at least 2001.

In addition to the "Structures in good condition" indicator, the MTQ uses three other management indices (scored from 0 to 100, with 100 being the optimal value) to measure three parameters that describe the overall condition of the inventory of structures within the highway system (Québec 2010b):

- The structure performance index (SPI) makes it possible to assess the capacity of the components to perform their role as part of the structure. This index is directly related to the safety of the structures. The score of 85.1% that was obtained in 2009 demonstrates that the structures are safe.
- The structure functionality index (SFI) measures whether the bridge meets the needs of users in terms of load-bearing capacity, the number of lanes, the presence of sidewalks, etc. The 91.5% score that was achieved in 2009 demonstrates that the structures do a good job of meeting the needs of users.
- The structure materials index (SMI) makes it possible to measure the condition of the materials making up the components of the structure. The 2009 score of 70.4% highlights the need for intervention in order to improve the condition and ensure the durability of structures.

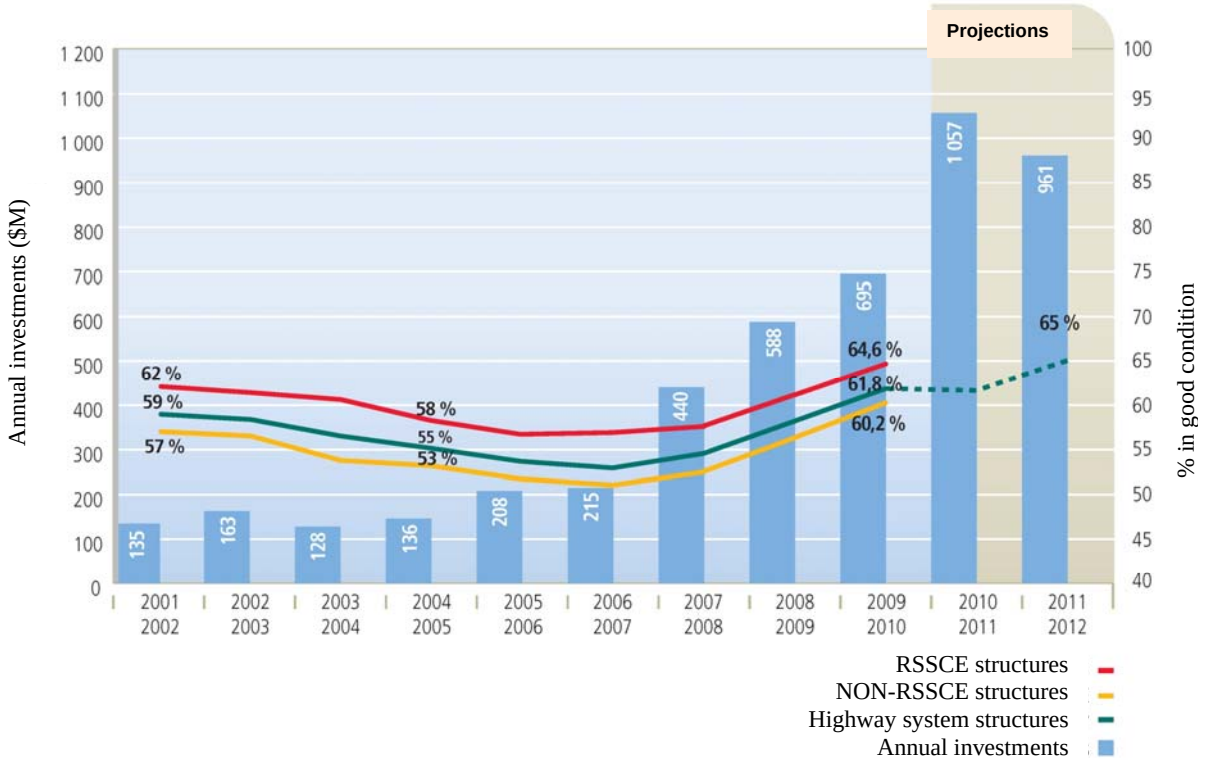

Figure 4 – Change in the condition of structures and annual investments

2.2.2.3 Culverts

Figure 5 shows the change in the condition of culverts within the highway system, depending on whether or not they are part of the RSSCE. The results obtained to date suggest that the objectives for 2012 should be met if the investments made in recent years are maintained.

Figure 5 – Change in the condition of culverts and annual investments

The largest and most rapid action undertaken in 2007 within the framework of the QIP will make it possible to reduce the CMD that was evaluated in 2008 by 2023, which is the end of the term for the plan. The strategies that have been adopted will continue to be refined through an iterative process as detailed data pertaining to roads, structures, and culverts are accumulated.

2.3 Public transit and GHG

The objective of the *Québec Public Transit Policy* (Québec, 2006), which was introduced on June 16, 2006, is to increase the use of public transit throughout Québec. The goal is to increase public transit ridership by 8% between now and 2012 by increasing service capacity by 16% over the same period.

The policy is being implemented by the MTQ through the enhancement or creation of public transit support programs, capital assets programs for public transit, and programs aimed at increasing service capacity.

Some major investment projects, such as the rehabilitation of fixed assets and the replacement of rolling stock in the Montréal Metro, represent unavoidable interventions, because this equipment had reached the end of its service life. In addition, the resumption of commuter train service in the Greater Montréal Area around the beginning of the millennium was carried out with used equipment, and therefore, much of it must now be replaced.

The renewal of the bus fleets for transit services and the rehabilitation and renewal of infrastructures and equipment for bus networks (e.g.: garages) are just as important to the various population centres in Québec.

The investments required in public transit for the period from 2006 to 2015 have been estimated at a minimum of $4.6B. These investments include the completion of projects that are already underway, the implementation of projects aimed at replacing or renewing existing infrastructures and equipment, and several improvement projects.

Other projects related to the expansion and improvement of these services may be the subject of requests for inclusion in the government's three-year public transit investment plan in coming years. Based on estimates presented by the public transit agencies, these investments could reach $3.4B.

3. INFRASTRUCTURES AND CLIMATE CHANGE

3.1 Climate Change Action Plan

Since 2006, the government of Québec has demonstrated true leadership in the area of climate change by adopting a number of policies aimed at reducing greenhouse gas (GHG) emissions, including the *Québec Public Transit Policy*, the *Québec Energy Strategy 2006-2015*, and the *2006-2012 Climate Change Action Plan*. These initiatives have earned Québec recognition as a leader in North America in the fight against climate change.

The action plan entitled "*Québec and Climate Change: A Challenge for the Future, 2006-2012*" (Québec, 2006b) comprises 26 actions aimed at reducing GHG emissions and

adapting to the impacts of climate change. With this plan, Québec is aiming to achieve a 14.6 Mt reduction in its GHG emissions in 2012, a target that is 6% below 1990 levels, which exceeds that of the Kyoto Protocol (5.2% below 1990 levels). Total funding for the CCAP comes to $1.55B over six years.

On November 23, 2009, just prior to the Copenhagen Summit, the government of Québec renewed its commitment to reducing its GHG emissions by announcing its decision to adopt a GHG emissions reduction target of 20% below 1990 levels by 2020. In doing so, Québec set itself an ambitious goal that is comparable to that of the European Union.

The adoption of this target necessitates priority intervention in the transport sector. This is a very ambitious challenge, given that the transport sector in Québec is the largest producer of GHG, accounting for 40.7% of total emissions in 2007.

3.1.1 Ministerial *Sustainable Development Strategy*

On March 31, 2009, the MTQ announced a *Sustainable Development Strategy* (Québec, 2009) and a *Sustainable Development Action Plan 2009-2013* (SDAP) (Québec, 2009b).

The strategy represents a rallying call for the organization and a supporting tool for taking the concept of sustainable development into account in all of its products, services, and activities. It is applied in the MTQ's three areas of intervention, namely the planning of transport activities, the management of transport networks, and governance. It solidifies the MTQ's commitment with respect to sustainable development for the period 2009-2013.

The strategy consists of six prongs that relate directly to the themes of this report. The first one: "Climate change and energy efficiency: Reducing GHG emissions and using energy more efficiently" calls for the MTQ to implement certain actions in the freight transportation and passenger ground transportation sectors, among other things. The anticipated result of the combination of these measures is a potential reduction and elimination of 1,590 kt of GHG emissions by 2012.

3.1.2 Territorial sustainable mobility plans

The territorial sustainable mobility plans are the result of integrated and multimodal planning aimed at directing and managing the requirements in terms of the transportation of persons and goods from a perspective of social equity, environmental protection, and economic efficiency over a 10-year horizon. Their development is directly related to the second prong of the strategy: "Land-use planning: Planning the development of transportation systems from a land-use and sustainable development perspective".

The implementation of these fifteen territorial plans will make it possible to improve the efficiency and integration of transportation systems, giving concrete expression the new governmental and ministerial guidelines respecting transportation planning in the various regions.

The MTQ's territorial managers play a leadership role throughout the process of developing these plans by ensuring effective cooperation with their partners, including municipalities, other government departments, public transit authorities, and major trip generators.

3.2 Adapting infrastructures to climate change

Establishing adaptive measures in the area of transportation infrastructures constitutes an essential tool in terms of dealing with the effects of climate change on mobility. In order to accomplish this, the MTQ conducts research in collaboration with the universities and various partners, and has identified five priority issues: the vulnerability of airport infrastructures in Nunavik as a result of the thawing of the permafrost; the vulnerability of marine infrastructures in Nunavik as a result of the reduced ice cover and recurring storms; coastal erosion in the St. Lawrence Gulf and Estuary; the decreasing water levels and flows of the St. Lawrence River; and the increase in freeze-thaw cycles.

It is important to point out that Nunavik occupies the northern third of the province of Québec, covering an area of approximately 507,000 km². There is no land-based link between Nunavik and southern Québec. By way of indication, the distance between Montréal and Kuujjuaq, which is the administrative centre of Nunavik, is 1,500 km as the crow flies.

3.2.1 The vulnerability of airport infrastructures in Nunavik as a result of the thawing of the permafrost

Since 1984, the MTQ has been the owner of 13 airport infrastructures in Nunavik, 9 of which are built on permafrost with a high ice content, which makes them very sensitive to global warming. Significant degradations caused by that thawing of the permafrost can now be observed, such as settling along or right across embankments, cracking, and dysfunctional drainage networks. In order to ensure the durability and safety of these airport structures, it is essential to learn more about the characteristics of permafrost and adaptive techniques in order to quantify the magnitude of the effects to be anticipated over the long-term and to properly assess the risks. Upon completion of the condition surveying and research work, an adaptation strategy will be developed and implemented with a view to protecting the vulnerable infrastructures.

3.2.2 The vulnerability of marine infrastructures in Nunavik as a result of the reduced ice cover and recurring storms

Given the absence of a road network linking the villages of Nunavik to each other and to southern Québec, maritime transport plays a critical role. Since 1999, the Canadian and Québec governments have financed the construction of marine infrastructures in 14 villages in Nunavik. An almost total lack of available data has been noted, especially with respect to water levels and storm regimes (trajectories, recurrence, intensity), which constitutes critical information for the purposes of establishing safety factors when designing marine infrastructures. Research projects are underway to collect data for use in estimating the effects of climate change on these marine structures in order to be in a better position to assess the risks and vulnerabilities.

3.2.3 Coastal erosion in the St. Lawrence Gulf and Estuary

The coastal infrastructures of the St. Lawrence Gulf and Estuary (bank protection structures, roads, jetties, etc.) are sensitive to climate change. By way of example, route 199, which runs along a narrow strip of sand in the Îles-de-la-Madeleine, is vulnerable to storm surges and to the rise in sea level. In recent years, it has been observed that coastal erosion is trending upward. Research projects are underway with a view to characterizing the vulnerable sites and infrastructures. These projects will assist in

identifying intervention priorities and planning both the construction and the rehabilitation and maintenance of structures.

3.2.4 Decreasing water levels and flows of the St. Lawrence River

The MTQ is interested in the decrease in water levels and flows of the St. Lawrence River, which threaten to impact maritime transport. This decrease may cause carriers to lighten vessels in downstream ports, which would require the use of a greater number of vessels to transport a given quantity of freight. As a result, the competitiveness of certain ports within the commercial network may be affected. For this reason, the MTQ is contributing to the initiatives and research projects of the Consultative Committee on Navigation (CCN) of the *St. Lawrence Action Plan (SLAP)* (Québec 1988), among others.

3.2.5 Increase in freeze-thaw cycles

The increase in freeze-thaw cycles is largely responsible for the damages caused to pavements. On the one hand, freezing damages the structure of pavements, and can result in the formation of ice lenses that lift the pavement, possibly causing cracks to appear in the surface course. On the other hand, freezing weakens the pavement, thus increasing the damages caused by heavy traffic, and can cause ruts and cracks to appear. It is important to note that more frequent freeze-thaw cycles exacerbate these pavement degradation phenomena.

4. CONCLUSION

Through its commitments and its actions, Québec plays a leading role in North America in terms of reducing greenhouse gas emissions, which are partly responsible for the climate change effects that have already been seen, and those that are yet to come. The northern territories and the coastal zones are the first to suffer the effects of climate change, and therefore, the MTQ has undertaken research projects that should allow it to gain a greater understanding of the phenomena at work, and to make the necessary changes to its intervention methods in order to adapt them to the changes that are occurring.

The *Québec Infrastructures Plan* is also part of a sustainable development approach aimed at giving Québec safe and good quality infrastructures to support the economic development of the province from a perspective of intergenerational equity. These major investments, combined with the implementation of effective intervention strategies, have delivered decisive results over the first three years of the implementation of the highway system renewal plan. Continuous improvement of these strategies, focusing on the durability of infrastructures, will make it possible to improve the quality of life for users and for the population of Québec as a whole over the medium and long term.

BIBLIOGRAPHY

Bilan de l'état des chaussées du réseau routier supérieur québécois 2009 [report on road conditions within the Québec highway system, 2009], Québec, 2010, 30 pp., http://www.mtq.gouv.qc.ca/portal/page/portal/Librairie/bpm/bilan_etat_chaussees 2009.pdf.

Bilan de l'état des structures du réseau routier supérieur québécois 2009 [report on the condition of structures within the Québec highway system, 2009], Québec, 2010, 33 pp., http://www.mtq.gouv.qc.ca/portal/page/portal/grand_public/vehicules_promenade/reseau_ routier/structures.

Act to promote the Maintenance and renewal of public infrastructures, R.S.Q., c. M-1.2, Québec, 2007, 4 pp., http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch /telecharge.php?type=5&file=2007C38F.PDF.

Québec and Climate Change: A Challenge for the Future, 2006-2012 Action Plan, Ministère du Développement durable, de l'Environnement et des Parcs, Québec, 2006, 52 pp., http://www.mddep.gouv.qc.ca/changements/plan_action/.

Sustainable Development Action Plan 2009-2013, Ministère des Transports du Québec, Québec, 2009, 36 pp., http://www.mtq.gouv.qc.ca/portal/page/portal/ministere/ministere/developpement_durable.

St. Lawrence Action Plan, Québec-Canada, Québec, 1988, http://www.planstlaurent .qc.ca/sl_bm/interventions_g/psl/phase_IV/comites/navigation/accueil_f.html.

Québec Infrastructures Plan: Foundations for Success, Secrétariat du Conseil du Trésor, Québec, 2007, 17 pp., http://www.tresor.gouv.qc.ca/fileadmin/PDF/publications/plan-infrastructure.pdf.

Québec Public Transit Policy – Passenger Transportation in Québec: Better Choices for Citizens, Ministère des Transports du Québec, Québec, 2006, 76 pp., http://www.mtq.gouv.qc.ca/portal/page/portal/grand_public/transport_collectif/politique_ quebecoise_transport_collectif.

Government Sustainable Development Strategy 2008-2013 – A Collective Commitment, Ministère du Développement durable, de l'Environnement et des Parcs, Québec, 2007, 87 pp., http://www.mddep.gouv.qc.ca/developpement/strategie_gouvernementale/.

Sustainable Development Strategy 2009-2013, Ministère des Transports du Québec, Québec, 2009, 63 pp., http://www.mtq.gouv.qc.ca/portal/page/portal/ministere/ministere/developpement_durable.