

Vehicle Noise Mitigation Study Report

Prepared for:

City of Saskatoon

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Executive Summary

Soft dB has undertaken a vehicle noise mitigation study for the City of Saskatoon to research, review, engage stakeholders and recommend suitable mitigation measures.

Vehicle noise includes noise from defective mufflers or other faulty equipment and noise generated from street racing, stunting, hard acceleration and hard braking. In Saskatoon, vehicle noise issues represent the majority of noise complaints received by the Saskatoon Police Service and the number of tickets issued for vehicle noise has been significantly increasing over the last 4 years. The objectives of the study were to identify Saskatoon's current context, identify best practices (in terms of regulation, enforcement approach, mitigation strategy, public awareness), complete engagement with key stakeholders; elaborate and assess guiding principles and recommend vehicle noise mitigation measures.

The analysis of the Saskatoon context was conducted based on existing literature and documentation provided by the City of Saskatoon and meetings from the stakeholders' engagement process. The stakeholders were the Saskatoon Police Service (SPS), Saskatchewan Government Insurance (SGI), Saskatchewan Health Authority (SHA), Saskatoon Traffic Safety Prosecutions (STSP) and several departments of the City of Saskatoon.

Although the City of Saskatoon Noise Bylaw covers vehicle noise, in practice, only the provincial Saskatchewan Traffic Safety Act (TSA) and the Saskatchewan Vehicle Equipment Regulations (VER) are used by police officers. Enforcement consists of on-the-spot checks conducted by SPS officers located at roadside. For excessive noise coming from defective mufflers or other faulty equipment exhaust system, VER is the more commonly used legislation as it is relatively more objective and easier to enforce and articulate in court. In addition to a summary offence ticket, SPS officers can also give a vehicle inspection ticket, which, as part of the SGI's Unsafe Vehicle Program, requires vehicle owners to take their vehicle for inspection (at the cost of the vehicle owner) in an SGI-certified vehicle inspection station and to complete all necessary repairs. If vehicle owners do not comply, their registration renewal may be refused. As for soft enforcement measures, SPS Traffic Unit conducts an educational campaign called the #KeepItDown project that includes a social media campaign on Twitter, voluntary testing clinics set up for motorcyclists, and traffic unit representatives speaking to local media outlets about the enforcement initiative.

Several issues and challenges have been identified through the Saskatoon context analysis. Issues and challenges common to any city include the limitations of complaint-based-only approaches, the use of subjective criteria to assess compliance, the resource limitations associated with manned enforcement and the regulatory and enforcement limitations associated with aftermarket mufflers and "Original Equipment Manufacturer" (OEM) exhaust modes. Issues and challenges specific to Saskatoon include the lack of vehicle noise data to obtain a complete picture of the situation, current noise complaints management, resource limitations of the SGI inspection program, and limited and outdated city-produced information on vehicle noise.

A review of 16 municipal and 6 provincial regulations was conducted. No particular municipal or provincial regulation particularly stands out. Saskatoon legislation has a lot of similarities with the regulations under review and has no striking deficiencies.

A vehicle noise mitigation strategy includes any type of measures that might reduce the impact caused by excessively noisy vehicles. While law enforcement initiatives are usually at the core of mitigation strategies, soft measures such as awareness campaigns, lobbying actions, regulation updates, public consultation, and noise checking events have been implemented to encourage and promote behavioural change without penalizing

offenders. The most relevant vehicle noise mitigation initiatives conducted by Canadian cities in the last 10 years are summarized and presented. Edmonton and Calgary stand out as having conducted pilot projects that include the development and/or trial of technology dedicated to vehicle noise enforcement.

Press coverage on vehicle noise issues and mitigation initiatives were analyzed for 20 Canadian cities, no positive press coverage on vehicle noise initiatives has been found. The lack of documentation around successful initiatives highlights the complexity of mitigating vehicle noise issues.

The use of technologies to enforce vehicle noise is discussed. Class 1 and class 2 sound level meters are currently used to enforce noise-level based regulations. Noise and road monitoring technologies have been developed for the pilot projects in Calgary and Edmonton. Recent examples of noise camera systems are described. While several noise camera systems are currently being tested, there is, at the time of drafting this report, no commercially available solution dedicated to vehicle noise.

Building on the learning from the context analysis and the review of vehicle noise regulations and mitigation strategies, three guiding principles and 16 recommendations are presented. Guiding principles promote a multifaceted approach with enforcement, education, and public awareness that focuses on reducing the impacts of vehicle noise on the community through a public health lens.

The collection and analysis of quantitative and qualitative data on vehicle noise (acoustical data, public feedback) is recommended to effectively measure and predict community reactions to noise and improve guidance on enforcement measures. An improved complaints management system using the future 311 customer service system should be promoted by the city. Recommendations on a public awareness campaign are provided including on possible content for marketing and communications and responsive signage.

Technical knowledge is provided on metrics, approaches and technology to collect and analyze vehicle noise-related acoustical data.

One enforcement approach is suggested to overcome the current enforcement limitations and improve the enforcement efficiency and effectiveness. It consists of using pre-screened noise and road traffic data to identify excessively noisy vehicles and send an inspection notice to the vehicle owner mandating attendance at a vehicle noise inspection site.

While SPS should remain the main enforcing agency, it is suggested to dedicate internal resources to develop in-house noise expertise within the City of Saskatoon and sustain a staff position whose main task is to coordinate and support the development, implementation and management of the vehicle noise strategy.

Lobbying actions directed at the Minister responsible for SGI are suggested to implement higher vehicle noise fines, stronger inspection policies and tougher penalties for street racing and stunt driving infractions.

Finally, the main components of the strategy and their expected outcomes are summarized, a nine-step approach to develop and implement the strategy is detailed together with short-term (less than a year), mid-term (between one year and two years) and long-term (beyond two years) action plans.

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1 Introduction

The City of Saskatoon is the biggest and the most populous city in the province of Saskatchewan and like any other metropolitan cities, Saskatoon also experiences occurrences of excessively noisy road vehicles. The noise emanating from these excessively noisy road vehicles have become a rising concern that disrupts the peace and tranquility of the residents of the city.

According to the Saskatoon Star Phoenix article dated September 16, 2019, titled, *"Saskatoon police offer vehicle noise solutions"* modified automobiles with aftermarket mufflers are responsible for the majority of noise complaints received by Saskatoon Police Service. According to the CBC news article dated September 19, 2019, *"Saskatoon police revving up tickets for noisy vehicles"*, the number of tickets issued to the offenders has been significantly increasing between 2017 and 2019 and that the 8th Street and Spadina Crescent are the main roads generating a large portion of the noise complaints.

In addition to the motor / exhaust system noise, noise generated by street racing, stunting, hard acceleration and hard braking are other major sources responsible for causing the noise annoyance which has resulted in ever-growing distress calls reporting noise nuisance to the Saskatoon Police Service.

Over the last few years, vehicle noise issues have been addressed by City Council and the Standing Policy Committee on Transportation. The Administration investigated channels that could be further explored to mitigate vehicle noise and presented the results in an information report (Vehicle Noise – May 2020 Update).

Several mitigation strategies were identified as worthy of investigation: noise bylaw review; education campaign, lobbying provincial government, noise action plan. The Administration recommended retaining a consultant to conduct further research to develop an understanding of effectiveness, scope of work and cost of potential mitigation strategies. The City of Saskatoon has commissioned a vehicle noise mitigation study to research, review, engage stakeholders and ultimately recommend suitable mitigation measures for vehicle noise. A Request for Quotations was issued by the City of Saskatoon in January 2021 and the contract was awarded to Soft dB in March 2021.

This report presents the key outcomes, findings and recommendations of the vehicle noise mitigation study conducted by Soft dB between April and September 2021. The structure of the report is as follows:

- project scope;
- current Saskatoon context;
- best practice review;
- guiding principles and recommendations;
- conclusion.

2 Project Scope

2.1 Project Brief

The primary aim of this project is to research, review, engage stakeholders and recommend suitable mitigation measures for vehicle noise in the City of Saskatoon.

The types of noise that fall under the umbrella of vehicle noise include excessive noises produced by the engine, exhaust, and tires. These include noise from defective mufflers or other faulty equipment, and noise generated from street racing, stunting, hard acceleration and hard braking.

A distinction is made between vehicle noise and traffic noise and between vehicle noise mitigation strategies and traffic noise mitigation strategies. Traffic noise mitigation strategies focus on reducing overall noise generated by non-excessively noisy road vehicles with traffic control and management (changing traffic volumes, composition, speed or driving patterns) and road design measures (noise barriers, quiet pavement). Vehicle noise mitigation strategies focus on reducing noise from excessively noisy vehicles. The objectives of the study are summarized below:

- identify Saskatoon's current vehicle noise mitigation strategy including the legislation, stakeholders' engagement, enforcement, awareness and communication plan;
- identify the international best practices in terms of, regulation, stakeholders' engagement, enforcement, objective assessment methodology, awareness and communication;
- conduct engagement with key stakeholders;
- explore and assess vehicle noise mitigation measures appropriate for the City of Saskatoon context, and;
- share the study results and conclusions.

2.2 Methodology

The first step was to fully review any existing literature and documentation provided by the City of Saskatoon and /or regarding the Saskatoon context including:

- the noise regulatory context;
- noise complaints data;
- locations on the Traffic Noise Sound Attenuation Monitoring List;
- 2015/2016 and 2020 noise monitoring campaigns, and;
- the enforcement analysis approach and technologies.

One of the main objectives of reviewing Saskatoon's current policies and regulations was to identify gaps and deficiencies that may prevent an effective implementation of the various regulatory tools. A literature review of the other Canadian and international approaches was conducted based on:

- an existing extensive database of Canadian, North American and international regulations developed by Soft dB;
- available public information on cities and jurisdictions websites and social media;
- press articles and local media news on vehicle noise monitored during the duration of the study;
- research papers, available from online academic libraries.

Cities were chosen from across North America using purposeful sampling. In general, the focus was on cities with population similar or greater than Saskatoon population. Due to the interest in local noise management strategies, the main focus of the review was on smaller cities within the Canadian Prairies. All municipal and provincial-level regulations were considered. The review was focused on determining best practices in terms of:

- regulatory texts;
- city-produced public information on vehicle noise
- operational human and technical resources allocated to the strategy;
- technology used;
- awareness campaign(s), outreach and communications.

For several cities with particular and/or interesting strategies, the persons responsible were contacted to further explore their strategies for enforcing the regulations and/or managing vehicle noise mitigation.

The stakeholders involved in the stakeholders' engagement process are the following:

- City of Saskatoon Transportation Department;
- Saskatoon Police Service (SPS);
- Saskatchewan Government Insurance (SGI);
- Saskatchewan Health Authority (SHA);
- Saskatoon Traffic Safety Prosecutions (STSP);
- City of Saskatoon Recreation and Community Development Department;
- City of Saskatoon Sustainability Division;
- City of Saskatoon Bylaw Enforcement Division.

For each stakeholder; 2 "individual" meetings (one kick-off meeting and, one "working" session were held which focused on the research results and possible strategies and noise mitigation measures. Following each "individual" meeting, one group meeting with all the stakeholders was conducted which focused on the research results, preliminary analysis of the engagement process and preliminary recommendations and noise mitigation measures.

Considering the project timeline and COVID-19 context, all meetings with the stakeholders were virtual meetings.

Vehicle noise mitigation measures were identified from the literature review and the Saskatoon context analysis and based on the stakeholders engagement meetings. A detailed list of recommendations has been developed by the Soft dB project team.

Table 1: Date of the stakeholders' engagement meetings

Meetings		Date
Kick-off meetings	SHA	April 27 2021
	SGI	April 28 2021
	STSP	May 3 2021
	SPS	May 6 2021
	City of Saskatoon internal stakeholders	May 13 2021
Second meeting	SHA	May 27 2021
	SGI	June 11 2021
	STSP	June 15 2021
	SPS	June 18 & 21 2021
	City of Saskatoon internal stakeholders	July 6 & 8 2021
Group meeting		July 8 2021

3 Current Saskatoon Context

3.1 Introduction

The goals of the analysis of the Saskatoon Context were to understand and review the City of Saskatoon's vehicle noise context, to identify the main challenges, strengths, weaknesses and opportunities.

The following questions were addressed:

- What is the present state of knowledge on the vehicle noise problem?
- How is the vehicle noise problem currently assessed?
- What is the current regulatory context?
- What is the current enforcement process?
- What is the vehicle noise complaints management process?
- What is the current vehicle noise mitigation strategy including outreach and communication campaigns?
- How have the vehicle noise issues been addressed by the City of Saskatoon over the last 20 years?
- Who are the main stakeholders and what is their current role and involvement?

The literature review was based on the review of:

- the internal "background" documentation provided by the City of Saskatoon (noise complaints data, internal reports and communications);
- the available public information on the City of Saskatoon and other stakeholders' websites.

The analysis based on the results of the literature review and the stakeholders' engagement meetings is presented as follows:

- legislation;
- mitigation strategy;
- state of knowledge on the vehicle noise problem;
- stakeholders;
- issues and challenges.

3.2 Legislation

Vehicle noise in the City of Saskatoon is covered by the Saskatoon Noise Bylaw, the Saskatchewan Traffic Safety Act (TSA) and the Saskatchewan Vehicle Equipment Regulations Act (VER).

Table 2 presents the sections of each legislation that covers vehicle noise. Vehicle Equipment Regulations (VER) only focus on muffler noise: it states that the vehicle shall have a muffler that effectively reduces combustion noise. Therefore, any muffler modifications that are meant to increase the level of noise it emits constitutes an offence.

The scope of the TSA vehicle noise section is broader than VER. It includes any types of *unnecessary* noise generated by a vehicle but it does not define or specify in greater detail what an unnecessary noise is.

Table 2: Vehicle noise legislation that applies to the City of Saskatoon

Legislation	Vehicle noise section
Saskatchewan Traffic Safety Act	<p><i>Excessive noise prohibited - Section 215</i></p> <p>No person shall create or cause the emission of any loud and unnecessary noise from a motor vehicle, a part of a motor vehicle or any thing or substance that the motor vehicle or a part of the motor vehicle comes into contact with.</p>
Saskatchewan Vehicle Equipment Regulations	<p><i>Muffler</i></p> <p>18 The vehicle shall have a muffler that effectively reduces combustion noise</p>
City of Saskatoon Bylaw No. 8244 The Noise Bylaw	<p>General Prohibition</p> <p>5 (2) Factors for determining whether a sound is unreasonably loud or excessive include, but are not limited to, the following:</p> <ul style="list-style-type: none"> (a) the proximity of the sound to sleeping facilities, whether residential or commercial; (b) the land use, nature and zoning of the area from which the sound emanates and the area where it is received or perceived; (c) the time of day or night the sound occurs; (d) the duration of the sound; (e) the volume of the sound; (f) the nature of the sound; (g) whether the sound is recurrent, intermittent or constant; and (h) the nature of the event or activity from which the sound emanates. <p>Motor Vehicle Noise Prohibition</p> <p>5.1 Without limiting the generality of section 5, for the purpose of regulating motor vehicle noise, the following provisions shall apply:</p> <ul style="list-style-type: none"> (a) no person shall operate a motor vehicle in such a manner that it makes, continues, causes to be made or continues or suffers or permits to be made or continued any unreasonably loud or excessive noise; (b) in determining whether the noise from a motor vehicle is unreasonably loud or excessive, a justice may consider any of the factors mentioned in subsection 5(2); and (c) no person shall operate a motorcycle within the City of Saskatoon that is capable or emitting any sound exceeding 92 dB(A), as measured by a sound level meter at 50 centimetres from the exhaust outlet while the engine is at idle; or emitting any sound exceeding 96 dB(A), as measured by a sound level meter at 50 centimetres from the exhaust outlet while the engine is at any speed greater than idle. <p>Testing Permitted</p> <p>5.3 The operator of any motor vehicle shall, upon the request of a police officer, take the motor vehicle to any site designated by the police officer and have the motor vehicle tested for sound.</p> <p>Failure to Comply with Request of Police Officer</p> <p>5.4 It shall be an offence for the operator of any motor vehicle to refuse to take the motor vehicle to any site designated by the police officer and</p>

The subsection 5.1 (a) of *The Noise Bylaw* is very similar to section 215 of the TSA. It covers any types of *unnecessary* noise generated by a vehicle, creating a redundancy with the provincial TSA.

The subsection 5 (2) specifies the factors that can be considered for determining whether a vehicle noise is unreasonably loud or excessive.

The subsection 5.1 (c) focuses only on motorcycles exhaust noise and includes measurable noise level limits and a specific measurement methodology. The subsection 5.1 (a) of *The Noise Bylaw* allows SPS to send the vehicle to a noise inspection / testing site and have it inspected and tested.

3.3 Mitigation strategy

3.3.1 Enforcement and prosecution processes

The major component of the current strategy is regulation enforcement. In Saskatoon, vehicle noise is enforced by the Saskatoon Police Service (SPS) and the vast majority of the traffic infraction tickets are given by the traffic unit of the SPS. Enforcement consists of on-the-spot checks conducted by police officers located at roadside that observe and listen to vehicles passing by and assess if a vehicle is being driven in a manner which offends the vehicle regulations. Although, both the municipal and the provincial legislation cover vehicle noise, in practice, when a vehicle noise ticket is given, only the provincial legislation (TSA and VER) is used by police officers. [1]

For driving behaviour-related noise (stunting, squealing tires, racing), the conviction will typically be stunting or racing instead of a noise violation.

The noise level limit for motorcycle noise in *The Noise Bylaw* has only been used for educational purposes during education awareness campaigns.

There is no strict rule regarding the use of the provincial acts rather than the city bylaws but, generally speaking, the provincial acts are easier to deal with in terms of prosecution and carry stricter penalties. Therefore, police officers tend to use the provincial acts. For excessive noise coming from the exhaust system, although the two provincial legislation VER and TSA can be used, VER is the more commonly used legislation as it is relatively more objective and easier to articulate / justify in court. [1]

TSA gives enforcement the ability at roadside to determine subjectively if this vehicle is excessively loud or not. The subjective assessment consists of comparing the vehicle noise to adjacent traffic or other vehicles on the road. However, since the “*unnecessary*” term is not defined in greater detail nor specifies with noise level limits, the enforcement implies a degree of subjectivity and requires the police officer to be able to provide subjective evidence.

VER requires officers to have a minimal amount of mechanical knowledge as they will be required to inspect the exhaust system roadside and then describe the offending equipment in court.

One major advantage of using the VER offences is the ability for police officers to give, in addition to a summary offence ticket, a vehicle inspection ticket, which, as part of the SGI's Unsafe Vehicle Program, requires vehicle owners to take their vehicle for inspection (at the cost of the vehicle owner) in a SGI-certified vehicle inspection station and to complete all necessary repairs. In most cases, both the vehicle inspection notice and the summary offence ticket are issued at the same time but police officers can decide to only give a warning, a summary offence ticket, a vehicle inspection ticket or both of the latter two. Inspections are at the cost of the vehicle owner.

Usually for minor elements missing on a vehicle (i.e., headlights), when a vehicle inspection ticket is given, the vehicle owners are told to repair the vehicle and if they did not report it to SPS to show that the repairs have been made, SPS will send the inspection ticket to SGI. In the case of vehicle noise, a specific initiative has been established between SPS and SGI, SPS will immediately email that inspection ticket to SGI which then sends out a letter with a 30-day ultimatum that requires vehicle owners to take their vehicle for inspection and complete all necessary repairs. If vehicle owners do not comply, their registration renewal may be refused.

A person receiving a ticket can opt to pay their fine to avoid a court appearance, or choose to contest the ticket and appear in court. The police officer who issued the ticket is called to appear in court as a witness.

Figure 1 summarizes the vehicle noise enforcement and prosecution process in Saskatoon.

In order to convince the judge that the exhaust system did not effectively reduce the noise, officers are asked to articulate what they heard and provide an objective description as to why they were attracted to that vehicle in comparison to other vehicles. The main justifications / evidence used by the officers are:

- the vehicle is significantly noisier than the rest of the traffic;
- the officer was able to hear a vehicle over another which suggests that the exhaust has been modified.

Most of the police officers that deal with vehicle noise are traffic officers that have a good handle on vehicle noise issues and do not require additional training for court convictions of vehicle noise infractions. [2] During roadside inspections, police officers can use their camera or phone to record the noise. While they are not always able to capture the noise while the vehicle is passing by; when the recordings do capture the noise of the vehicle, the recordings are very useful and effective evidence in court.

In 2018, over the 94 tickets for that were issued, only one went to trial. Saskatoon Traffic Safety Prosecution (STSP) has usually been very successful at getting a vehicle noise conviction. [2]

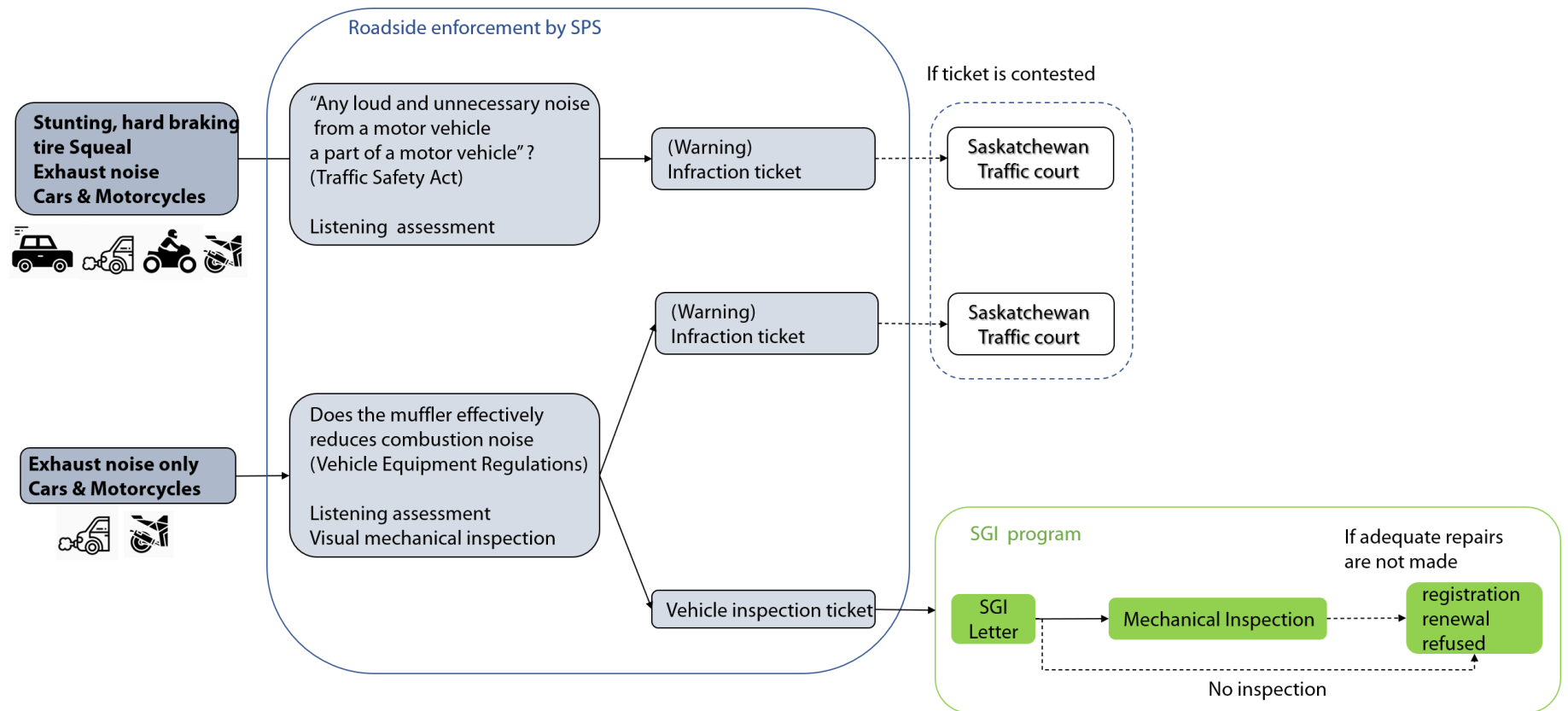


Figure 1: Summary of the vehicle noise enforcement and prosecution processes in Saskatoon

3.3.2 Soft measures and complaints management

Saskatoon's current vehicle noise mitigation strategy also includes "soft" enforcement measures that aim at encouraging and promoting behavioural change without penalizing offenders. During summer 2019, SPS Traffic Unit conducted an educational campaign called the #KeepItDown project that included:

- social media campaign on Twitter with the hash tag #KeepItDown which aimed to "educate motorists about the impact of noisy vehicles on their fellow citizens"; [3]
- voluntary testing clinics, set up for motorcyclists at various locations during one month assessing the compliance with *The Noise Bylaw* noise-level limits for motorcycles;
- motorcycle noise checkpoints where motorcycles were flagged into a testing area as part of an enforcement campaign;
- traffic unit representatives spoke to local media outlets resulting in several press articles and radio stories.

The idea was to conduct the educational campaign every year, starting in spring, [4] but the educational campaign did not take place in 2020 and 2021 because of the COVID-19 pandemic. Motorcycle noise level testing clinics originally started in 2014 when the noise level limit for motorcycle noise was added in *The Noise Bylaw* No. 8244.

Since 2019, the SPS Traffic unit, through its twitter account, has been maintaining a communication channel regarding vehicle noise issues, sharing information and news and answering public questions. Figure 2 presents several tweets from the #KeepItDown campaign on Twitter.



Figure 2: SPS Traffic Unit Tweets from the #KeepItDown campaign

Official communication on vehicle noise consists of a brochure from the Saskatoon Police Service available on its website (saskatoonpolice.ca) or by searching "Saskatoon vehicle noise" using a search engine (Figure 3).



Figure 3: Saskatoon Police Service Vehicle noise brochure header

Complaints to the police come from many different platforms and channels (phone, website, social media). The variety of platforms and channels used to address noise complaints makes it very difficult to effectively centralize them and to respond and follow up with every single person. [1]

There is no policy and procedures associated with vehicle noise complaints in the City of Saskatoon. [5] Figure 4 illustrates the origins of the noise complaints data provided by the City of Saskatoon and the large number of possible channels to address a vehicle noise complaint in Saskatoon.

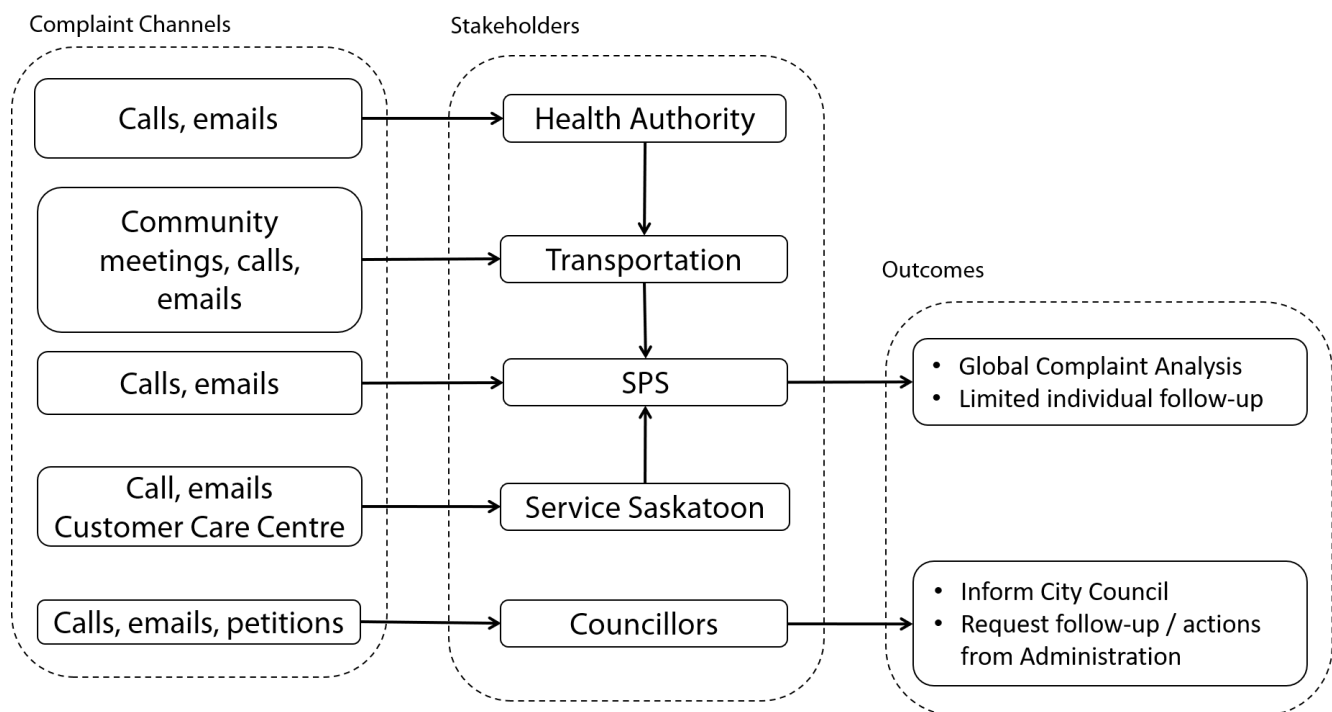


Figure 4: Vehicle noise complaints channels, stakeholders and outcomes

3.4 State of knowledge on the vehicle noise problem

Based on SPS observations, a number of complaints received are associated with street racing and stunting [1]. The category of vehicle that constitutes the bulk of this problem is “muscle” cars; the prevalence of cars with modified muffler systems has increased in recent years. [3]

These “muscle” cars are intentionally equipped with modified muffler systems to emit louder than factory engine noise by installing aftermarket muffler systems. Generally, they are not classic or collector cars, but rather widely available vehicles that are easy to modify and for which a wide variety of aftermarket accessories is available. Although some types of motorcycles can also generate loud noise, significantly fewer complaints are received about motorcycles. [3]

SPS regularly conducts analysis of vehicle noise situation based on field observations and analysis of the noise complaints it receives. The main sources of data on the vehicle noise problem are the vehicle noise complaints data and the vehicle noise charges / tickets data.

The acoustical data collected during the traffic noise monitoring programs do not fully inform the vehicle noise situation. The acoustical metric that was used is an equivalent sound pressure level in dB (LAeq) measured on a daily basis and “energy-averaged”¹ over 24 hours. This does not accurately quantify the noise peaks caused by excessively noise vehicles and the number of disturbing events.

SPS Traffic Noise Report from 2019, [6] presents an analysis of the vehicle noise situation including an analysis of the vehicle noise charges (tickets and warnings) distribution over time. The two graphics presented Figure 5 highlight the increase of “loud muffler” charges between 2014 and 2019 and the distribution of “inadequate muffler” charges and “unnecessary noise” charge over the first 8 months of 2019.

The number of charges for loud mufflers went from 60 in 2016 to more than 140 in 2018. The number of the “loud muffler” charges for year 2019 is incomplete as it only includes charges written for the first 8 months. The number of charges over the first 8 months of 2019 shows a significant increase of charges during spring and summer. Other than the noise complaints data and the vehicle noise charges / tickets data, there is no report or data on the impact of vehicle noise on Saskatoon’s population.

The number of tickets does not necessarily correspond to a number of offenders. There are repeat offenders that received more than one charge over one month or one year.

Moreover, complaining constitutes only one facet of all reactions to noise annoyance. Noise complaints are not necessarily a reliable measure of noise annoyance and health effects of vehicle noise.

Table 3 presents the number of tickets and warnings issued for vehicle noise between 2018 and 2019 provided by SPS in October 2021.

¹ Equivalent sound pressure level is a continuous sound pressure level (SPL) of noise averaged over time which contains the same amount of energy as that generated by the actual and varying sound levels being measured. This is not an arithmetic average.

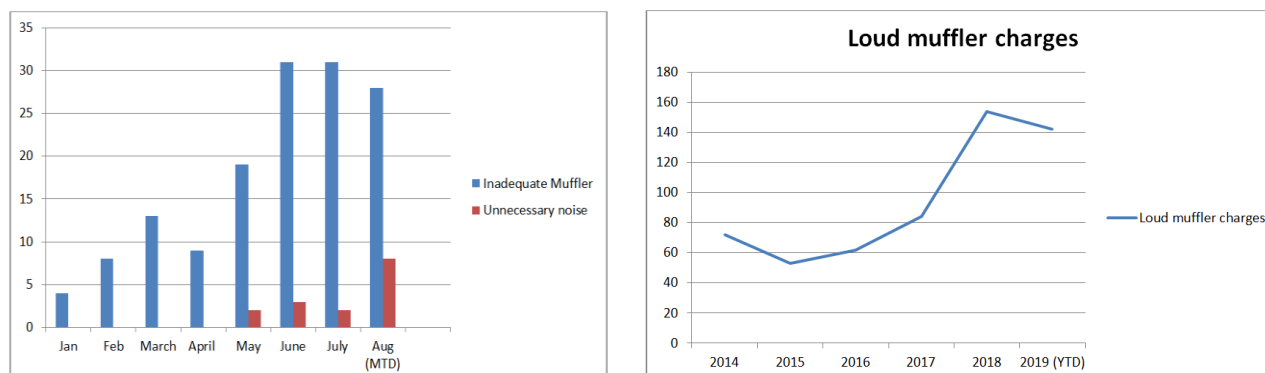


Figure 5: Loud muffler charges (2014-2019*) and the distribution of "inadequate muffler" charges and "unnecessary noise" charges over the first 8 months of 2019, SPS Traffic Noise Report, 2019

Table 3: Number of tickets and warnings issued for vehicle noise in 2018, 2019 and 2020

Year	Type of infraction		
	Inadequate muffler		"Cause loud and unnecessary noise"
	Tickets	Warnings	Tickets
2018	70	63	24
2019	135	56	26
2020	216	102	37

Although the vehicle noise problem is seen by SPS as a year-round problem, it is of greater concern during the spring, summer and fall, particularly on Friday, Saturday, and Sunday commencing mid afternoon to late evening. [3] The cruise night weekend in August has been identified by SPS as a problematic event.

There are several well-known noise-complaint hotspots: 8th Street, Spadina Crescent East, 22nd Street West. In terms of enforcement, 8th Street is the street for which a large part of the efforts has been concentrated on. In 2019, 41% of all vehicle noise tickets issued in the city were issued on 8th Street. [6]

However, vehicle noise issues are not only located in these hotspots. The analysis of the noise complaints data also shows noise complaints occurring in several residential neighbourhoods: Fairhaven, Rosewood, Lakewood Suburban Centre, Pacific Heights/Kensington, Evergreen, Spadina Crescent and Whiteswan Drive.

3.5 Stakeholders

This section presents the main stakeholders, their roles, responsibilities and competencies in the current vehicle noise mitigation strategy in Saskatoon. This methodology of the stakeholders' engagement is described in section 2.2.

3.5.1 Saskatchewan Health Authority

SHA is responsible for the delivery of safe, high quality health care for the entire province. SHA involvement with city projects includes providing data, making policy analysis, talking to Council and committees, advocating for various issues, providing policy framework and recommendations. [7] SHA expertise would be very valuable for the data analysis and public consultation components of the vehicle noise strategy.

SHA interests regarding noise include indirect health effects: sleep disturbance, mental health, stress, etc. [7] SHA receives complaints and petitions regarding noise issues and usually refers residents to SPS or Transportation. SHA aims to produce evidence informed strategies and look at it from a policy perspective as well as create supportive environments. [7]

3.5.2 Saskatchewan Government Insurance

SGL sets the provincial standards and works with enforcement agencies across the province providing training and technical / regulatory support including vehicle noise issues. For example, SGI has provided guidance to the SPS regarding Society of Automotive Engineers (SAE) standards. Twice a year, SGI provides "light vehicle enforcement training" to enforcement officers (usually from the traffic safety divisions). [8]

It is worth noting that SGI has conducted a vehicle noise pilot project in the past (in 2003-2004) that included decibel testing at roadside and in SGI inspection facilities using SAE standards. The pilot program was done in collaboration with the City of Regina and Saskatoon. [8]

The origin of the pilot program was a request from the government, to assist enforcement in the ability to determine excessively loud vehicles. [9]

3.5.3 Saskatoon Traffic Safety Prosecutions

Vehicle noise offences under the provincial legislation are heard in Saskatchewan Traffic Safety Court. The Traffic Safety Prosecutors prosecute the vehicle noise offences during traffic court trials. The Traffic Safety Court in Saskatoon handled a limited number of court cases related to vehicle noise infractions (3 trials in 2019, 2 in 2020 and 5 in 2021). [10]

3.5.4 Saskatoon Police Service

In Saskatoon, vehicle noise is enforced by the Saskatoon Police Service (SPS); the vast majority of the traffic infraction tickets are given by the traffic unit of the SPS (Section 3.3.1). Its involvement, described in detail in section 3.3, includes:

- the enforcement of the vehicle noise regulations using mostly roadside spot checks at strategic locations;
- the analysis of noise data complaints for enforcement;
- the testing clinics for motorcycles;
- the social media campaign on Twitter #KeepitDown;

- the collaboration with SGI for the SGI inspection program.

SPS technical resources include five sirometers, two sound level meters and one anemometer, all used for the noise testing clinics and the education awareness campaign.

3.5.5 City of Saskatoon

The City of Saskatoon Transportation Department manages the overall transportation network, including the Traffic Noise Sound Attenuation Program and the Traffic Noise Monitoring Program whose goal is to assess and monitor traffic noise from high volume roadways to the outdoor spaces in surrounding residential areas and assess the need for noise barriers.

In addition to traffic noise (overall noise generated by non-excessively noisy vehicles), the Transportation Department has been partly responsible for dealing with vehicle noise issues. In 2020, the Transportation Department has investigated and presented to the Standing Policy Committee on Transportation channels that could be further explored to mitigate vehicle noise. [11] The City of Saskatoon Transportation Department is also currently receiving and answering vehicle noise complaints. [5].

The Bylaw Compliance team receives and deals with commercial and industrial noise complaints, more generally noise issues that are enforced under the noise bylaw or the City *Zoning Bylaw*.

3.6 Issues and Challenges

The issues and challenges that have been identified from studying the Saskatoon context and meeting with the stakeholders are presented in this section. The guiding principles and recommendations designed to address these challenges and issues are detailed in Section 5.

Some of the issues and challenges are common to vehicle noise and apply to any city. It includes the limitations of complaint-based only mitigation approach, the use of subjective criteria to assess compliance, the resource limitations associated with manned enforcement, and the regulatory and enforcement limitations associated with aftermarket mufflers and “Original Equipment Manufacturer” (OEM) exhaust modes.

Other issues and challenges are specific to the Saskatoon context. It includes lack of vehicle noise data to obtain a complete picture of the situation, current noise complaints management, resource limitations of the SGI Inspection program, and limited and outdated city-produced information on vehicle noise.

Complaint-driven mitigation approach: Regulatory or complaint-based approaches alone are limited in their effectiveness in abating vehicle noise. Without a comprehensive strategy, a reactive regulatory-only approach usually leads to low enforcement and increased residents' dissatisfaction.

Subjective criteria to assess compliance: The use of a subjective criterion (rather than a numerical noise-level limit) to assess if a vehicle is unnecessarily noisy has been questioned in court several times in North America. Using a subjective assessment is less robust than using an objective measurable method based on noise level limits. Opinion of unnecessary noise may vary from person to person and subjective assessment may lead to more uncertainty in compliance, possibility of vagueness arguments and arbitrary enforcement.

Cities have usually argued successfully that requiring a police officer to use a sound meter unreasonably restricts cities' ability to control the level of noise in the community and most of the time, courts have agreed on the fact that officers are capable of determining when noise from motor vehicles is unreasonably disturbing the peace.

The main disadvantage of an objective / measurable (noise level-based) criteria is the technical resources (mostly sound level meters) and expertise its enforcement requires.

Manned Enforcement: The main enforcement approach for vehicle noise consists of roadside checks conducted by police officers. It is resource-intensive, time-consuming and requires the presence of officers. Once the officer is no longer present, the problematic behaviour can return. Manned enforcement implies gaps in enforcement coverage and is not suited with the limited resource (proportionally compared to other road safety issues) that is allocated to vehicle noise enforcement. Another common enforcement challenge is the fact that officers are not mechanics and have limited knowledge in the matter. In cases where it may be required, officers are not necessarily comfortable at conducting a mechanical inspection (looking for exhaust cut-outs or if the muffler is cracked / has holes for example). Figure 6 shows a mechanical inspection conducted by a police officer at roadside.

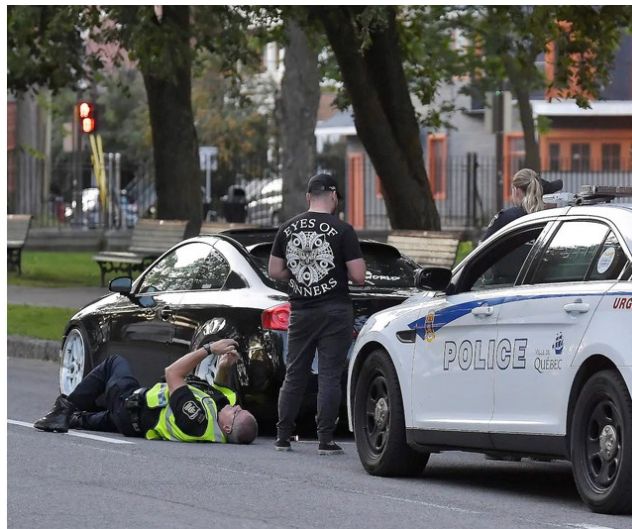


Figure 6: Mechanical inspection conducted by a police officer at roadside (Photo credit: Didier Debusschère, Journal de Québec)

Regulatory limitations associated with aftermarket mufflers and OEM exhaust modes: Aftermarket mufflers are not illegal and since aftermarket mufflers are not recognized or stamped by Transport Canada, it makes it very difficult for regulators to identify if a particular component is legal or illegal.

Some cars have noisier exhaust modes that can be activated by only pushing a button (“sport exhaust mode” of the Ford Mustang GT for example). These car exhaust modes are allowed by Transport Canada and makes roadside enforcement very difficult.

Vehicle noise data: The review of the background information provided by the City of Saskatoon highlights that the current data does not obtain a complete picture of the vehicle noise situation. There is no existing vehicle noise complaint database and it is a tedious process to extract complaints from the SPS database [1]. The variety of platforms and channels used to address noise complaints makes it very difficult to effectively centralize all vehicle noise complaints. [1]. Other than the noise complaints data (that represent a distorted picture of the problem), the City of Saskatoon does not have data on the health and welfare impacts of vehicle noise, what the perception of vehicle noise by its citizens is and to which degree citizens are impacted in terms of sleep disturbance, annoyance or dissatisfaction.

Noise complaints management: There is no existing official process to collect and follow-up vehicle noise complaints. With the complaints coming in from various sources, it is very difficult to respond and follow up with complainants. [4]

SGL Inspection program: The current SGL Inspection program is labour intensive for both SPS and SGL and very limiting in the number of people that can be involved. The success of this initiative is based on individual traffic officers' willingness and availability to write vehicle noise offences and then, send them to the Traffic Unit Staff Sergeant who acts as a liaison between SPS and SGL. There is currently no process or form for muffler noise-related issues so that the officers can send them directly to facilitate and scale up the process. One of the limitations of the SGL program inspections is that the mechanics at the SGL certified garage only look at the mechanical aspects of the vehicle during inspections; no subjective noise assessment is conducted. Some vehicle owners that receive a vehicle inspection ticket and are required to take their vehicle for inspection would temporarily install the original or appropriate muffler for the inspection and then revert to an illegal / noisier exhaust system afterwards. A vehicle noise inspection is only valid for the time of the inspection; there is no guarantee that the vehicle will comply in the future.

City-produced information on vehicle noise: The city-produced information on vehicle noise is limited (just one brochure available on SPS website) and presents contradictory information with regards to the actual enforcement process and the use of The Noise Bylaw.

4 Best practice review

4.1 Vehicle noise regulations

4.1.1 Summary of Canadian provincial and municipal regulation

In most major cities in Canada, vehicle noise is covered by both municipal and provincial regulations. Provincial and municipal vehicle noise regulations address the two main types of vehicle noise:

- inherent mechanical noise of a vehicle (usually due to a modification or a defect of exhaust system parts);
- the noise associated with driving behavior (stunting, hard acceleration, etc.).

In provincial and municipal regulations, these two types of vehicle noise issues are covered by articles that can be regrouped in four categories:

- articles that only focus on vehicle mechanical parts with the prohibition of certain exhaust system modifications;
- articles that only focus on the vehicle mechanical /combustion noise with the prohibition of excessive or unusual exhaust noise;
- articles that only focus on the vehicle mechanical noise using measurable noise level limits;
- articles with a broad and general scope that focus on the overall excessive or unnecessary noise generated from the use of a vehicle and/or a particular driving behaviour.

Table 4 provides examples of the four categories of vehicle noise regulations articles with excerpts from provincial and municipal regulation.

Table 4: Categories of vehicle noise regulations articles – examples from provincial and municipal regulations

Categories of vehicle noise regulations articles	Regulatory text(s)	Excerpts
Vehicle mechanical parts: prohibition of exhaust system modifications	Ontario Highway Traffic Amendment Act	<i>"No person may use a muffler cut-out, straight exhaust, gutted muffler, Hollywood muffler, by-pass, or similar device on a motor vehicle or motor-assisted bicycle."</i>
Vehicle mechanical/combustion noise: prohibition of excessive or unusual exhaust noise	Saskatchewan Vehicle Equipment Regulations	<i>"The vehicle shall have one or more mufflers that effectively reduce combustion noise."</i>
	Alberta Motor Vehicle Equipment Regulation Act	<i>"A motor vehicle propelled by an internal combustion engine must have an exhaust muffler that cools and expels the exhaust gases from the engine without excessive noise and without producing flames or sparks."</i>
	Ontario Highway Traffic Amendment Act	<i>"Every motor vehicle or motor-assisted bicycle must be equipped with a muffler in good working order and in constant operation to prevent excessive or unusual noise and excessive smoke."</i>
Vehicle mechanical noise: measurable noise level limits	Saskatoon Bylaw No. 8244; The Noise Bylaw, 2003	<i>"No person shall operate a motorcycle within the City of Saskatoon that is capable or emitting any sound exceeding 92 dB(A), as measured by a sound level meter at 50 centimetres from the exhaust outlet while the engine is at idle; or emitting any sound exceeding 96 dB(A), as measured by a sound level meter at 50 centimetres from the exhaust outlet while the engine is at any speed greater than idle."</i>
	Kelowna Bylaw No. 10573 Amendment No. 9	<i>"A person shall not cause or permit sound from a motor vehicle to exceed 90 dB(A), as measured at 50 centimetres or more from the motor vehicle."</i>
Overall excessive noise generated from the vehicle and/or particular vehicle use or driving behaviour	Saskatoon Bylaw No. 8244; The Noise Bylaw, 2003	<i>"No person shall operate a motor vehicle in such a manner that it makes, continues, causes to be made or continues or suffers or permits to be made or continued any unreasonably loud or excessive noise."</i>
	Saskatchewan The Traffic Safety Act T-18.1	<i>"No person shall create or cause the emission of any loud and unnecessary noise from a motor vehicle, a part of a motor vehicle or any thing or substance that the motor vehicle or a part of the motor vehicle comes into contact with."</i>
	British Columbia Motor Vehicle Act Regulations B.C. Reg. 26/58	<i>"No person shall start, drive, turn or stop any motor vehicle, or accelerate the vehicle engine while the vehicle is stationary, in a manner which causes any loud and unnecessary noise in or from the engine, exhaust system or the braking system, or from the contact of the tires with the roadway."</i>

A summary of the review of the municipal vehicle noise regulations, undertaken for 16 Canadian cities is presented in Table 5.

In Canadian municipal vehicle noise regulations, noise level limits for motorcycles are more common than noise level limits for motor vehicles:

- Seven cities: Saskatoon, Kelowna, Edmonton, Toronto, Guelph, Windsor, Calgary (out of the 16 cities under review) have a vehicle noise regulation with a noise level limits for motorcycles;
- Two cities, Kelowna and Calgary, have a regulation that includes noise level limits for motor vehicles.

Table 5: Reviewed Canadian cities (with population) vehicle noise regulations

Cities	Population	Regulatory text	Noise level limits	
			Motorcycle	Motor Vehicles
Toronto	2,930,000	Toronto Municipal Code Chapter 591, Noise	X	
Montreal	1,780,000	R.R.V.M. c. B-3. Règlement Sur Le Bruit.		
Calgary	1,336,000	Bylaw No.26M96	X	X
Ottawa	995,000	Bylaw No 2017-255		
Edmonton	981,000	Bylaw No. 14600 City Policy C506A	X	
Winnipeg	750,000	City of Winnipeg By-Law 2479/80		
Vancouver	675,000	Bylaw No.9344 (Noise regulation abatement)		
Québec	542,000	R.V.Q 978		
London	405,000	Bylaw No. PW-12-19004		
Saskatoon	273,000	Bylaw No. 8244; The Noise Bylaw, 2003	X	
Windsor	234,000	Bylaw No. 6716	X	
Regina	230,000	Bylaw No. 6980		
Guelph	135,000	By-law Number (2000)-16366	X	
Kelowna	132,000	Bylaw No. 10573 Amendment No. 9	X	X
Red Deer	104,000	Bylaw No. 3383-2007		
Victoria	92,000	Bylaw 03-012		

A summary of the review of the provincial vehicle noise regulations undertaken for the 6 most populated Canadian provinces is presented in Table 6.

Table 6: Reviewed Canadian Provincial vehicle noise regulations

Province	Regulatory text(s)	Noise level limits	
		Motorcycle	Motor Vehicles
Alberta	Alberta Motor Vehicle Equipment Regulation Act Alberta Traffic Safety Act		
British Columbia	Motor Vehicle Act Regulations B.C. Reg. 26/58	X	X
Manitoba	The Highway Traffic C.C.S.M. c. H60		
Ontario	Highway Traffic Act, R.S.O. 1990, c. H.8		
Québec	Highway Safety Code Chapter C-24,2	X	
Saskatchewan	The Traffic Safety Act T-18.1 Vehicle Equipment Regulations, 1987, V-2.1 Reg 10		

Only two provincial regulations include noise level limits: Quebec regulation includes noise level limits only for motorcycles while the province of British Columbia regulation includes noise level limits for both motor vehicles and motorcycles.

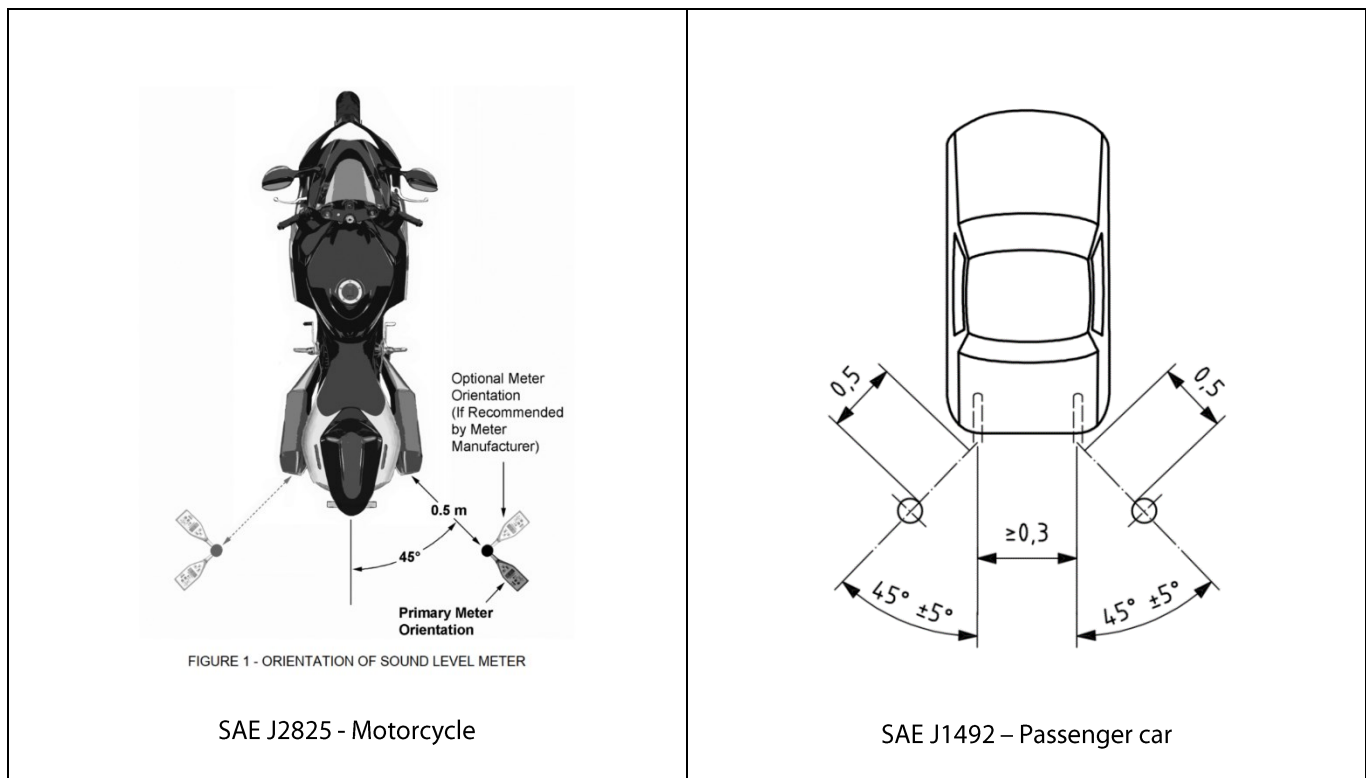
Section 4.1.2 describes the different noise level limits and the measurement methodologies associated with noise-level based regulations. In the most recent provincial and municipal regulation updates, the trend has been towards the use of the noise levels limits to further strengthen the legality and enforceability of the noise bylaw. Indeed, as already mentioned in Section 3.6, the use of a subjective criteria (with terms such as excessive or unnecessary noise) implies a degree of subjectivity in the enforcement which can lead to compliance uncertainty, possibility of vagueness arguments and arbitrary enforcement.

In summary, no particular municipal or provincial regulation particularly stands out. Saskatoon legislation has a lot of similarities with the regulations under review and has no striking deficiencies.

4.1.2 Noise level limits and measurement methodologies

Noise-level based regulations used in the Canadian municipal and provincial regulations (for motorcycles and motor vehicles) are based on stationary measurements of the exhaust noise.

The main methodology for measuring exhaust noise is based on SAE J2825 Standard (Measurement of Exhaust Sound Pressure Levels of Stationary on-Highway Motorcycles) for motorcycles and SAE J1492 (Measurement of Light Vehicle Stationary Exhaust System Sound Level Engine Speed Sweep Method) for passenger cars (Figure 7). The use of a standardized methodology ensures that tests are repeatable and reliable. Roadside measurements are relatively efficient, the instrumentation required (a sound level meter, a microphone with windshield and tripod) is simple to use, robust and compact.



For motorcycles, SAE J2825 standard describes test procedures for stationary measurements and also provides exhaust noise level (dBA) limits (Table 7). According to the standard, the noise level limits are based on a comprehensive study of a wide variety of on-highway motorcycles tested with both original equipment and aftermarket exhaust systems.

Table 7: SAE J2825 standard' s exhaust noise level limits

Engine Configuration	Test Procedure	Noise level limits dBA
All	Idle Test	92
Less than 3 cylinders or more than 4	Set RPM Test or Swept RPM Test	96
Engines with 3 or 4 cylinders	Set RPM Test or Swept RPM Test	100

In most cities that have noise level limits for motorcycles (Saskatoon, Kelowna, Edmonton, Toronto, Guelph, Windsor) use SAE J2825 exhaust noise level limits and test procedures. Calgary's Noise Bylaw stands out with different noise level limit and test procedure:

"noise measured at 96 decibels (dBA) or more as measured by a sound pressure level meter at any point of reception"

Noise level limits of Quebec's regulation depends on the class of road vehicles (motorcycle or moped) and the engine operating modes: engine runs at a constant or variable speed, engine is idling (Table 8).

Table 8: Province of Quebec's noise level limits for motorcycle and moped

Classes of road vehicles and engine operating modes		Noise level limits measured in dBA (A-weighted decibels)
Motorcycle	Engine runs at a constant or variable speed	100
	Engine is idling	92
Moped	Engine runs at a constant or variable speed	90
	Engine is idling	82

British Columbia's regulation (*Motor Vehicle Act Regulations, MVAR*), specifies maximum allowable noise level limits for the noise generated by the vehicle engine, any auxiliary engine or the exhaust, depending on the class of vehicle (Table 9). MVAR indicates that the vehicle is tested in an inspection station but neither the engine operating mode nor the assessment methodology are specified.

Table 9: Province of British Columbia's noise level limits for motorcycle and motor vehicles

Classes of vehicles	Noise level limits, dBA
Light duty	83
Gasoline-driven heavy duty	88
Motorcycles	91
Diesel-driven heavy duty	93

According to reports from Vancouver Police Board Service and Policy Complaint Review Committee, [12]

"The MVAR uses outdated terminology referring to provincial "inspection stations", which have been replaced with Designated Inspection Facilities (DIF). The CVSE Vehicle Inspection & Standards program stipulates that private and commercial vehicle inspections are performed by trade qualified mechanics that are authorized through CVSE as Authorized Inspectors."

"The testing procedures most commonly used by VPD members are the SAE J1492 OCT2008 "Measurement of Light Vehicle Stationary Exhaust System Sound Level Engine Speed Sweep Method" and the ISO 5130:2006 "Acoustics — Measurements of Sound Pressure Level Emitted by Stationary Road Vehicle."

"decibel meter tests are used in an attempt to reduce the number of tickets disputed for excessive noise infractions; and, in the event that a ticket is disputed, an objective test provides comprehensive and corroborating evidence in court."

Regulation that includes noise level limits for passenger cars are less common and there is no homogeneity of the noise limit values, from 83 dBA (British Columbia) to 96 dBA (City of Calgary's Noise Bylaw), Table 10.

Table 10: Noise level limits for passenger cars in Canadian legislation

Regulation	Noise level limits, dBA
British Columbia Motor Vehicle Act Regulations B.C. Reg. 26/58	83 (at 50 cm from exhaust)
Kelowna Bylaw No. 10573 Amendment No. 9	90 (at 50 cm from exhaust)
Calgary Bylaw No.26M96	96 (at any point of reception)

Table 11 presents noise level limits for passenger cars (when measured during stationary test) for several countries.

Table 11: Noise level limits for passenger cars (roadside stationary exhaust noise tests)

Country	Noise level limits, dBA
UK [13]	90 (at 50 cm from exhaust)
California (California Vehicle Code)	95
New Zealand Depending on the first registration year	90-95
Singapore Depending on the first registration year	L _{Amax} 97-113
Thailand	90

In several states in the United States such as Michigan, Connecticut, Washington and Florida, drive by measurements (instead of stationary tests) are used. The associated noise level limits depend on the speed and the age of the vehicle. They apply to measurements conducted at a distance of 50 feet (15.2 metres) from the centre of the lane of travel. Table 11 presents, as an example, the maximum allowable noise levels in Connecticut for drive-by measurements conducted at a distance of 50 feet. (Regulations of Connecticut State Agencies, Sec. 14-80a-4a.).

Table 12: Drive by noise level limits in Connecticut for any motor vehicle of less than 10,000 pounds

Vehicle Age	Type of site	Speed limit	Noise level limits, dBA Measured at a distance of 50 feet
Prior to Jan. 1, 1979	Soft Site	35 MPH or less	76
		above 35 MPH	82
	Hard Site	35 MPH or less	78
		above 35 MPH	84
On and after Jan. 1, 1979	Soft Site	35 MPH or less	72
		above 35 MPH	79
	Hard Site	35 MPH or less	74
		above 35 MPH	81

4.2 Vehicle noise mitigation strategies

A vehicle noise mitigation strategy includes any type of measures that might reduce the impact caused by excessively noisy vehicles. Law enforcement initiatives are usually at the core of any vehicle noise mitigation strategy. Law enforcement initiatives aim to enforce the regulations and, ultimately, penalize drivers that do not comply with the vehicle noise regulations. Vehicle noise issues in a city are the result of excessively noisy individual vehicles passing by at locations and times that negatively affect surrounding residents. Since just one individual excessively noise vehicle regularly passing by a residential area at night can cause great harm, it is crucial for a city to have enforcement procedures that are very responsive.

Section 4.1.1 presents a review of the vehicle noise mitigation strategies in Canadian cities. The use of the technology for vehicle noise enforcement such as noise monitoring system or noise cameras /radars is discussed in Section 4.2.2. Other mitigation strategies such as prevention actions and public awareness programs are presented in Section 4.2.3.

4.2.1 Vehicle noise mitigation strategies in Canadian cities

A review of the vehicle noise mitigation strategies in Canadian cities was conducted based on city-produced public information, press articles and social media communication.

For the majority of the cities for which vehicle noise mitigation initiatives have been documented, efforts are initiated and led by the city police service and consist of anti-vehicle noise enforcement campaigns with spot checks at roadside (based on subjective testing or using handheld sound level meters). Every year, usually at the beginning of spring, enforcement “blitz” campaigns are announced and covered by the local press. This press coverage helps raise awareness and is usually the only component of a city’s public awareness efforts.

In order to detect excessively noisy vehicles, online reporting tools are used such as the 311 residents service centre systems in Toronto, Vancouver, and Montreal. Reporting systems can be accessed by phone or webpages; some systems allow to submit digital evidence, such as photographs, videos and audio files.

In Toronto, residents are asked to contact 311 and provide data on vehicle noise issues in order to help Toronto Police services plan enforcement initiatives (Figure 8).

<p>Motor vehicles</p> <p>Clearly audible noise from vehicle repairs, rebuilding, modifying or testing:</p> <ul style="list-style-type: none"> • Is not permitted from 9 p.m. to 7 a.m. the next day, except until 9 a.m. on Saturdays, Sundays and statutory holidays <p>Motorcycle noise:</p> <ul style="list-style-type: none"> • Cannot exceed the approved standards • Will be measured by Bylaw Enforcement Officers using sound meters. <p>Unnecessary noise (for example, engine revving and tire squealing)</p> <ul style="list-style-type: none"> • Unnecessary noise that is clearly audible at point of reception is not permitted. <p>Bylaw Enforcement Officers do not have the authority to pull over moving vehicles and certain bylaw provisions exist only to allow for enforcement during joint traffic blitzes with Toronto Police Services. Traffic blitzes are often conducted over a short period of time (one or more weekends), at strategic locations targeting specific traffic violations.</p> <p>Data from noise complaints is crucial for the planning of enforcement initiatives with Toronto Police Services. Please contact 311 to submit all noise complaints, including motor vehicle noise complaints, so that the complaint data can be used to inform enforcement.</p>

Figure 8: Extract from the City of Toronto webpage on noise -Data from the vehicle noise complaints

Table 13 presents the most relevant vehicle noise mitigation initiatives conducted by Canadian cities in the last 10 years with the exception of the City of Saskatoon mitigation initiatives which are already described in detail in Section 3.3.

Several cities have included noise checking events as part of their vehicle noise strategy: Calgary (2012-2013), Saskatoon (2014-2019, see section 0), Toronto (2021).

Two cities, Edmonton and Calgary, stand out as having conducted pilot projects that include the development and/or trial of technology dedicated to vehicle noise enforcement. Edmonton's initiatives to tackle vehicle noise are the most advanced and documented initiatives in Canada ([14] [15] [16]). In 2018, after a 2-year-long first pilot project, the City of Edmonton Administration recommended the development of noise management continuum (Figure 9).

In 2019, at the end of the extended pilot project, Edmonton decided to take down the LED display boards that informed passing drivers how loud their vehicles were. Some drivers were generating additional noise when they started revving their engines to see just how loud they could get.

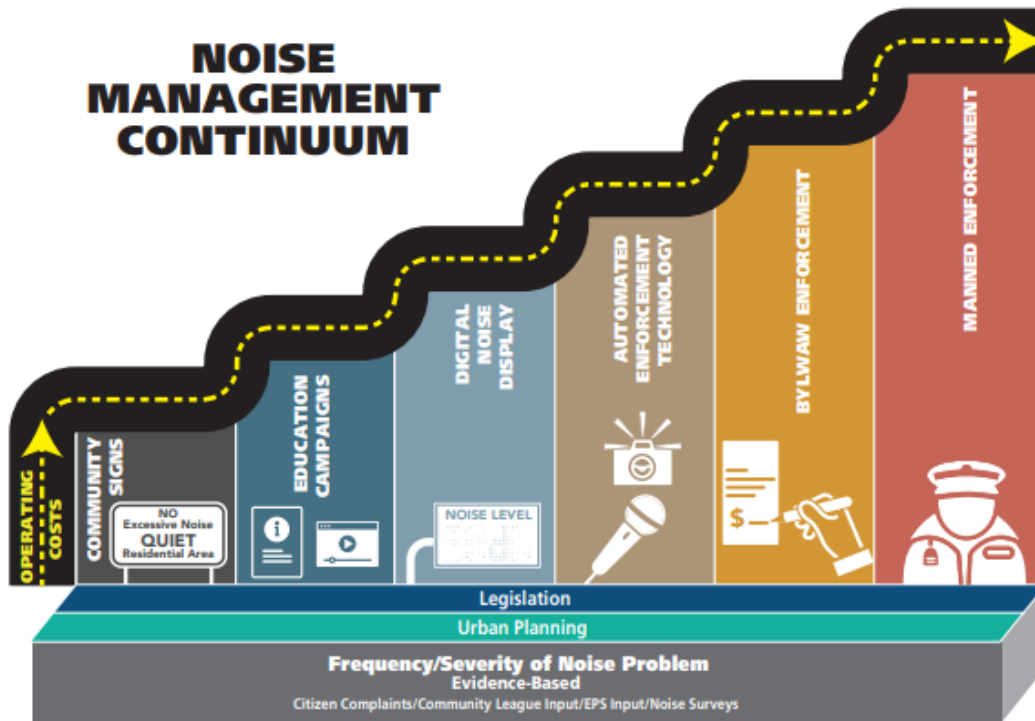


Figure 9: City of Edmonton “noise management continuum” recommended by the city administration at the end of the first pilot project in 2018

Press coverage on Vehicle noise issues and mitigation initiatives have been analyzed for the following cities: Calgary, Saskatoon, Vancouver, Regina, Edmonton, Ottawa, Toronto, Kelowna, Fredericton, Oakville, Québec, Brampton, Mississauga, Windsor, Niagara, Saanich, Red Deer, Montreal, Victoria, Barrie. No positive press coverage has been found. Despite the negative bias in the news coverage (negative news or statistics catch more attention), the lack of documentation around successful initiatives highlights the complexity of mitigating vehicle noise issues.

Table 13: Vehicle noise mitigation projects / strategies conducted by Canadian cities in the last 10 years noise tests

City	Date	Project / initiative - Description	Outcomes
Calgary, AB	2012 -2013	<p>Project "Noise snare"</p> <ul style="list-style-type: none"> conducted by City of Calgary Animal & Bylaw Services; call to register "vehicle in motion" noise complaints through 311; new bylaw provision; open houses: public testing; initial warning period; deployment of a vehicle noise monitoring system for 4 months (on average three times a week at various locations). 	<ul style="list-style-type: none"> Pilot project terminated after 2 years; main limitation: cost and inefficiency of the enforcement process using the monitoring system; in 2012, the system recorded 23,193 vehicles. Of those, 15 were found to be too loud. Only one \$270 ticket was issued and it was dismissed in court on a procedural issue; the use of the monitoring system is not required for court or charges, but provides some additional evidence for the officers to make a decision on charges.
Peachland, BC	2018	<p>Motorcycle noise awareness campaign</p> <ul style="list-style-type: none"> conducted by Kelowna RCMP; noise Watch Program, education and enforcement campaign; 10,000 drink coasters distributed to restaurants, cafes and pubs. The coasters include an image of a motorcycle, the words Hospitality, Tranquility and the slogan "Real rebels know when to pipe down". 	<ul style="list-style-type: none"> Not available
Winnipeg, MB	2019-2020	<p>Internal study on Traffic Calming Measures (Sunday Night Cruise)</p> <ul style="list-style-type: none"> investigate methods to control traffic flow and reduce speed and excessive noise on Sunday night cruise; data collection: observations and noise level measurements; investigate the use of Enforcement as a mitigation tool; <p>Investigate the use of noise cameras for enforcement.</p>	<p>Recommendations [17]:</p> <ul style="list-style-type: none"> develop standards and bylaws regarding protocols and practices measuring noise, obtaining and keeping necessary equipment maintained, inspected, etc. (similar to radar enforcement); the current enforcement of cruise night activity by the Winnipeg Police Service (WPS) is limited; Use of automated enforcement equipment requires legislative authority similar to current Photo Enforcement, which is under Provincial Review at present.

Edmonton, AB	2016-2018	<p>Pilot project on the development of in-house automated vehicle noise enforcement system</p> <ul style="list-style-type: none"> four high-complaint sites were examined; trial of a noise monitoring system; best practice review (regulations, technology, education campaigns). [18] [19] 	<ul style="list-style-type: none"> citizen complaints analysis, noise monitoring data analysis and best practice review conducted by the city administration; determine potential enforcement level threshold; recommendations in a vehicle noise report, [14] including the development of a staged approach/strategy with community signs, education campaigns, digital noise displays, automated enforcement technology, bylaw enforcement, manned enforcement.
	2018-2019	<p>Extended Pilot project</p> <ul style="list-style-type: none"> 8 locations were examined; collect additional data related to seasonality and times of day for vehicle noise; technology upgrades to improve reliability of information collected; test a preliminary threshold /baseline of 85 dBA; test LED display board as feedback signage. 	<p>Mixed results:</p> <ul style="list-style-type: none"> the technology couldn't tell the difference between sources of noise or identify offending vehicles to the precision required by court; the threshold /baseline level of 85 dBA was found to be too low and would capture city busses, street sweepers; the city's legal department required an officer on the scene in order to make the enforcement process hold up in court. <p>Noise Mitigation Plan [15] and recommendations provided by City Administration:</p> <ul style="list-style-type: none"> establish a stakeholder working group; develop a new enforcement approach; explore the possibility of using staff other than EPS officers to perform roadside testing; prioritize signage and education campaigns as a first step but LED feedback should not be deployed.
	2020	<p>Project TENSOR, (Traffic Enforcement Noise/Speed Offence Reduction)</p> <ul style="list-style-type: none"> 5 month long; use noise monitoring equipment to aid with detection and enforcement; one mobile and three static noise monitoring systems, through nine locations; test a new threshold of 95 decibels. 	<ul style="list-style-type: none"> charges: 1,684, vehicle-noise-related violations: 335 [20]; use of the noise monitoring system: resource-intensive and resulted in limited success in identifying a significant number of offenders; "fully automated noise enforcement is not quite ready to be launched in Edmonton just yet"; pilot cost: \$192,000 (equipment rentals, installations, monitoring, maintenance and software use) while fines generated just \$98,000; recommended next steps <ul style="list-style-type: none"> pursuing individual and industry education; using complaint data to identify target locations; exploring "new and cost-effective" technology for data gathering and resource deployment [16].

Oakville Halton Region, ON	2020	<p>Project #Noisemaker enforcement campaign:</p> <ul style="list-style-type: none"> conducted by Halton Regional Police Service; <p>Oakville council lobbying initiative aimed at the provincial government to prohibit the sale of tampered devices that create excessive noise.</p>	<p>In 2020, 1,420 charges across the region including:</p> <ul style="list-style-type: none"> 574 charges for having no muffler or an improper muffler; 396 charges for unnecessary noise; 12 racing/stunt driving charges. [21]
Ottawa, ON	2020-2021	<p>Project NoiseMaker education, awareness and enforcement campaign:</p> <ul style="list-style-type: none"> conducted by Ottawa Police Service traffic unit; targeting speeding, stunt driving and excessive noise; on weekends, at different locations “to catch stunt drivers and vehicles making excessive noise”. 	<ul style="list-style-type: none"> In 2020: an average of 10 tickets for stunt driving a week, 2,300 tickets, including about 1,400 speeding tickets; In 2021: 2500 tickets: stunt driving: 142 charges, Speeding: 1103, Improper muffler / excessive noise: 126).
Regina, SK	2020- 2021	<p>Project SPEED (Spring Public Education & Enforcement Drive) focusing on speeds, street racing and excessive vehicle noise</p> <ul style="list-style-type: none"> carried out by members of the Regina Police Service Traffic Safety Unit and Combined Traffic Services Saskatchewan (CTSS); one month long in 2020 and two-month long in 2021; lobbying initiative on vehicle noise: “to implement stricter measures regarding vehicle standards and inspection policies to try and tackle the vehicle noise caused by vehicle modification and work with the provincial on awareness and education campaigns”; [22] creation of a working group comprised of city traffic engineers and Regina Police Service focussing on stunting, racing and excessive vehicular noise issues. [22] 	<ul style="list-style-type: none"> 1,500 tickets were issues, over two thirds of them for speed.
Niagara, ON	2020-2021	<p>Operation Loud and Clear</p> <ul style="list-style-type: none"> conducted by the Niagara Regional Police Service; enforcement campaigns between April and September. 	<ul style="list-style-type: none"> In 2020, 52 Provincial Offence Notices for no muffler, improper muffler and unnecessary noise offences; In 2021, 307 charges including 82 for no muffler, 61 for improper muffler, 110 for unnecessary noise and 54 for other offences from loud vehicles. [23] [24]
Windsor, ON	2021	<p>3-month noise campaign with a focus on noisy vehicles</p> <ul style="list-style-type: none"> conducted by Windsor Police Service; following a new noise by-law in 2020; started with educational campaign with warnings. 	<ul style="list-style-type: none"> Not Available.

Fredericton, NB	2021	<p>City' s Vehicle noise bylaw updates:</p> <ul style="list-style-type: none"> • maximum decibel levels for motorcycles; • higher vehicle noise fines; • compliance notice / follow up [25]. 	<ul style="list-style-type: none"> • Not Available.
Barrie, ON	2021	<p>Project Wake Up Call</p> <ul style="list-style-type: none"> • enforcement blitz on vehicles making unnecessary noise; during the summer, twice a week during a four-week period. 	<ul style="list-style-type: none"> • Not Available.
Toronto, ON	2019	<p>Awareness and enforcement campaign</p> <ul style="list-style-type: none"> • conducted by Toronto Police and bylaw enforcement; • new bylaw including noise level limits for motorcycles; • dedicated noise team of 24 enforcement officers with more powers to issue compliance orders.; <p>Sound engineering experts are also helping develop "technical investigative techniques. [26]</p>	<ul style="list-style-type: none"> • "Toronto anti-noise blitz a flop" [27]; • 95 tickets, almost all for speed; • "Noise from vehicles was not observed much by the involved officers".
	2021	<p>Enforcement campaign / blitz</p> <ul style="list-style-type: none"> • conducted by Toronto Police and bylaw enforcement officers Enforcement events throughout the summer; • "strategic locations" for the enforcement campaign will be chosen based on complaints received by 311 and in-field data. <p>Three educational events where motorcycle riders can get their bikes tested.</p>	<ul style="list-style-type: none"> • Not Available.

4.2.2 On the use of technologies

Noise-level based regulations (section 4.1.2) require the use of sound level meters that have certain level of accuracy and performance. The two levels of accuracy that are accepted by noise-level based regulations are Class 1 and Class 2, as defined by standards such as IEC 61672-1:2013 and ANSI S1.4-1983(R2006). Class 1 sound level meters often called “precision” grade meters are more accurate than Class 2 sound level meters often called “general grade” meters (Figure 10).



Figure 10: Class 1 sound level meter used to measure exhaust noise of a passage car (following SAE J1492), [28]
(left) Piccolo II, Soft dB Class 2 sound level meter (right)

The vehicle noise technology, Noise Snare (Figure 11), used for the pilot project in Calgary in 2012-2013 was developed by a company based in Edmonton Street Noise Reduction Systems Ltd. The system was mounted on a vehicle, which was then parked and left unattended at a location.

A microphone was registering noise levels of passing vehicles. When a vehicle exceeding legal noise levels was detected, a video camera was capturing and recording footage of the vehicle along with audio. Information such as the time, date and location of the infraction were superimposed on the footage, along with the vehicle's sound level in decibels. Vehicle owners were identified via licence plate numbers on the footage. Police officers could simply view the DVD to detect excessively noisy vehicles or the system could also automatically notify them via text message or email.

At the end of the pilot project, the technology was found to be inadequate. Out of more than 23 thousand vehicles recorded, only 15 were found to be too loud and only one ticket was issued but was dismissed in court on a procedural issue. Calgary Police Service (CPS) ended up terminating the pilot project. Although it was not required for court or charges, CPS kept using the Noise Snare in order to provide some additional evidence in court.



Figure 11: Noise Snare system used by the City of Calgary during the 2012-2013 pilot project

The technology used for the Edmonton Pilot projects is an outdoor noise monitoring system and includes a sound level meter (enclosed in a weatherproof enclosure) and an outdoor measurement microphone with a windscreen (Figure 12). This type of system can come with “online” feature that allows to automatically upload measurements to a cloud (using a mobile phone network) and provide a 24/7 remote access to the measurements and recordings using a web-based interface. A camera and/or a licence plate reader device is used to identify the type of vehicle and the vehicle owner.

More information on outdoor noise monitoring system (including technical specifications required to measure and detect vehicle noise) are provided in Appendix A.3.



Figure 12: Vehicle noise monitoring system (with microphone and camera) and LED display board used by the City of Edmonton during the extended pilot project in 2018-2019

Over the last few years, noise camera or noise radar systems dedicated to vehicle noise have been developed and used for trials in several countries and cities. The main objective of these systems is to automatically detect and identify excessively noisy vehicles and, if needed, send tickets.

They usually include a camera, an automatic number plate reader and noise measurement system. The detection of excessively noisy vehicles is conducted by comparing the noise levels from passing vehicles against a suitable noise limit and/or using more advanced techniques such as spectral profile analysis or artificial intelligence

algorithms. Most of these systems are still under development and currently, there is no commercially available solution dedicated to vehicle noise.

A noise camera system developed by a UK-based company Intelligent Instrument incorporates two cameras to detect excess noise from road vehicles, identify the vehicles and take appropriate action against the driver if necessary. The system has been designed for law enforcement agencies, local authorities and police authorities. A 3-month trial was completed in London (UK) in 2020.

A noise camera system developed by Bruitparif (the Paris noise observatory) and called the Meduse (Figure 13) can localise loud vehicles using four microphones to triangulate the origins of a sound, identify the type of vehicle using acoustic analysis and identify the vehicle owners using CCTV footage. The Meduse has been tested in the Paris region since 2019 and will be tested in several other cities in France in 2021 and 2022.

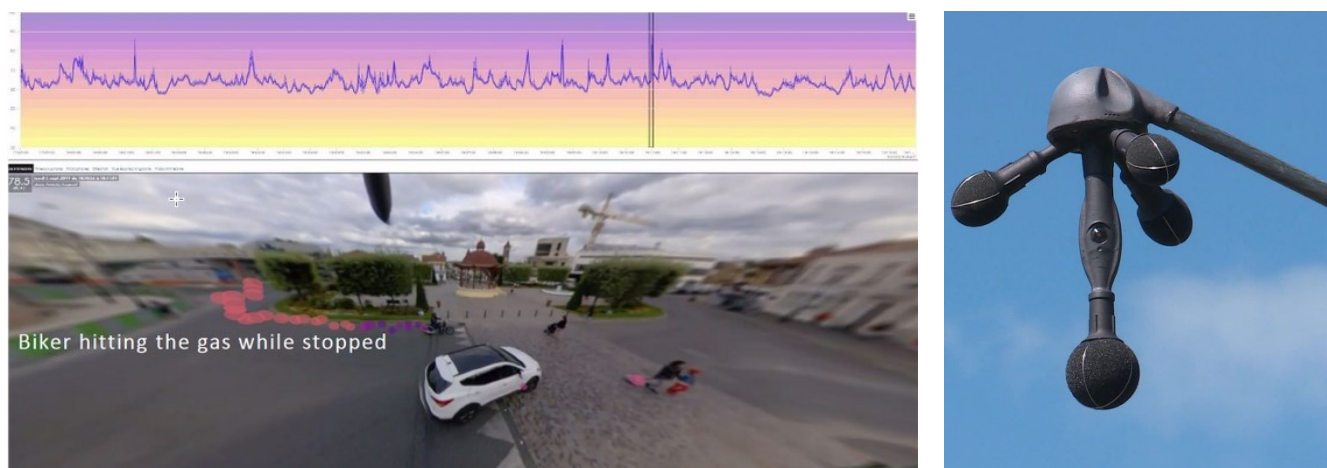


Figure 13: Meduse noise camera system developed by Bruitparif – Measurements' visualisation interface (left) and Meduse microphones setup (right)

4.2.3 Other mitigation strategies

In addition to enforcement, other strategy components such as awareness campaigns, lobbying actions, regulation updates, public consultation, noise checking events and pilot projects have been used as part of a vehicle noise mitigation strategy. Prevention actions and public awareness programs are called soft measures. They aim at encouraging and promoting behavioural change without penalizing offenders.

Measures against car cruises include the following:

- publicizing on social media and news outlets that they are aware of the car cruise and what action they would take if offences are committed;
- raising awareness of noise-related anti-social driving offences in newspapers and on social media;
- coordinating with neighbouring police forces or local authorities to ensure that enforcement doesn't result in disturbance elsewhere;
- patrolling the area where the car cruise is planned to take place and taking action against anti-social behaviour or anti-social driving, including dispersal of gatherings;
- engaging with car enthusiasts and people who attend car cruises to minimize disturbance and anti-social driving. [29]

Examples of public awareness campaigns focused on vehicle noise include:

- posters or flyers at key locations where drivers congregate, such as service centres and rest areas;
- free exhaust noise checking events;
- communications and education with mechanics and vehicle workshops;
- social media campaign to help people report excessively noisy vehicles;
- free distribution of drink coasters to restaurants, cafes and pubs in Peachland, BC. The coasters include an image of a motorcycle, the words Hospitality, Tranquility and the slogan “Real rebels know when to pipe down” (Figure 14);
- a petition with an humoristic content/video called “Stop noisy show-offs” (*Stop aux frimeurs bruyants*) by the Swiss noise abatement league (*Ligue Suisse contre le bruit*) (Figure 15). [30]



Figure 14: “Free drink coasters distributed to restaurants, cafes and pubs in Peachland, BC

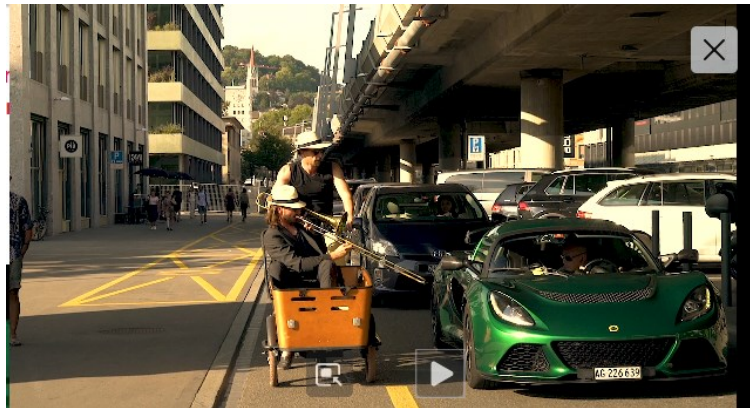


Figure 15: Screenshot of the humoristic video from the awareness campaign *Stop aux frimeurs bruyants* (Stop noisy show-offs) by the Swiss noise abatement league

5 Guiding principles and recommendations

Section 5 builds on the learning from the Saskatoon context analysis and the review of vehicle noise regulations and mitigation strategies and presents guiding principles and recommendations that fit with Saskatoon's specific context and needs.

5.1 Guiding principles for the strategy

Principle 1: The strategy's main goal should be with a public health perspective, focusing on reducing the impacts of vehicle noise on the community with health and welfare impacts as one of the main success indicators.

Historically, the City's approach to mitigating vehicle noise has been largely driven by complaints from residents. However, complaints can represent a distorted picture of the problem and are not the best indicator for evaluating the impact and magnitude of noise problems.

Complaints only partially reflect annoyance and more generally, health and welfare impacts. It is important for decision makers to be aware of this relationship and differentiate between complaints and annoyance. There are various target groups that typically don't complain to public authorities, among them are migrants, people with lower levels of education, people with fear or mistrust of the police, children. In the context of Saskatoon, individuals who live in low socioeconomic areas and who are potentially negatively impacted by the vehicle noise situation, are assumed not to be big complainers, as the City of Saskatoon does not receive many complaints from vulnerable and poverty-filled communities. [31]

In some cities where a new noise abatement strategy has been implemented city-wide, together with an appropriate public awareness campaign and a new noise complaint management system, an increase of the number of complaints has been observed right after the implementation of the strategy. It is worth noting that implementing an efficient (long-term) noise mitigation strategy does not necessarily imply an immediate reduction of complaints.

Principle 2: Design and implement the vehicle noise strategy for the entire city.

Although there are several well-known vehicle noise hotspots in Saskatoon (e.g., 8th Street, Spadina Crescent East), it is important to highlight that vehicle noise issues are not localized to these hotspots and complaints are occurring everywhere in Saskatoon. A city-scale strategy will be more appropriate than a localized-troubleshooting approach. [7]

Principle 3: Develop a data collection and analysis plan with acoustical data, public feedback and complaints data.

The analysis of the Saskatoon context (section 3) highlights a significant lack of available data on vehicle noise and no formal process to collect and analyze it.

Noise complaints inform only partially and with a bias that derives from the impact and magnitude of the vehicle noise problem. Infraction ticket data informs more on vehicle noise enforcement efforts than on the problem itself. The existing acoustical data collected during the Traffic Noise Sound Attenuation Program is not useful to assess the vehicle noise situation (see section 3.4). Quantitative and qualitative data is a key aspect for informing decision makers about the magnitude and scale of the problem.

Using the proper metrics and methodology, acoustical data is a major component to effectively measure and predict community reactions to noise and its expected health effects. However, since annoyance, sleep disturbance and other adverse health effects are not correlated to noise levels only, survey data and results from public consultation can also provide information on the community's perception and annoyance with adverse noise levels.

The residents' attitude and expectations regarding noise may change in the future and it is necessary to frequently or continuously collect and analyze data on vehicle noise.

Using an epidemiologic approach, public-health statistics and socioeconomic data are also very useful to assess and analyze associations between acoustical data and socioeconomic or geographical factors (using statistical modelling). Collecting and analyzing vehicle data can also:

- improve collaboration with stakeholders;
- improve the strategy over time by identifying, tracking and evaluating changes over time and establishing suitable criteria to set priorities for specific enforcement / interventions;
- improve public support and acceptance;
- inform public awareness campaigns.

5.2 Public Consultation

The main objective is to consult the public on their noise perception, suggestions and priorities for noise mitigation measures while increasing public acceptance for necessary measures.

The focus should be to inform and involve the people potentially affected by vehicle noise through public consultation. Using creative ways to reach vulnerable neighborhoods and populations is key to get input because they are not a population that readily engages in traditional municipal public consultation.

Recommendation 1: Develop and carry out a multifaceted public consultation strategy to solicit input from the public on the vehicle noise issue.

The public consultation strategy should include:

- survey /questionnaire in both paper and online format;
- focus groups, interviews and discussion with citizen groups affected by vehicle noise.

The distribution of the survey should cover all zoning areas, particularly residential areas in the vicinity of existing vehicle noise hotspots and vehicle noise complaints. The survey questions should be simple, brief, and clear. They should be designed to determine:

- whether there is a vehicle noise problem;
- what the main vehicle noise sources are (modified exhaust systems, street racing, stunting, etc.);
- what the perception of vehicle noise is;
- what the health and welfare impacts (annoyance, sleep disturbance, dissatisfaction) are;
- how many times and when the problematic events occur;
- whether there is public support and public acceptance to mitigate them.

The ISO standard ISO/TS 15666:2003 - Acoustics - Assessment of noise annoyance by means of social and socio-acoustic surveys can be used as a reference to draft the questions.

Hot spots should be identified using both survey data and public feedback, and in consideration of the following factors:

- number of excessively noisy cars and trucks travelling through an area;
- density of the population;
- number of people affected, annoyed and/or complaining;
- how residents perceive the noise problem;
- when the vehicle noise occurs;
- type of vehicle and the type of noise (street racing, stunting, modified exhaust noise, etc.).

Any noise mitigation measures require a certain level of public compliance to become effective. The expected public response should therefore be assessed during the public consultation process. Answers to the following questions can support this assessment:

- are the proposed enforcement approaches accepted by the general public (see section 5.6) ?
- can the compliance be increased by additional measures?
- how should the success of the mitigation strategy be assessed?

5.3 Complaints management

Taking care of noise complaints is important; indeed, authorities and/or officials' responsiveness to a complaint is a significant factor related to noise annoyance and a proper noise-complaint management system will actually reduce the adverse effects of noise on community relationships.

Improving the complaint management process will benefit the residents who want to fill in a complaint and receive feedback and the City of Saskatoon which is aiming to get a better picture of vehicle noise issues and use complaints data to improve its mitigation strategy. The main objectives for improving the complaints management process are the following:

- facilitate the filing of complaints process by simplifying and clarifying the complaint channels;
- provide information on the strategy, the enforcement mechanisms and the course of action undertaken and the expected results;
- collect information on the source(s) of complaints to improve guidance on enforcement measures.

Recommendation 2: Establish and implement an improved complaints management system for vehicle noise.

The provision of information on the actions taken would demonstrate to members of the public that the issue is being taken seriously. The Customer Care Center currently uses a knowledge base to gather information and answer questions when someone calls in to file a vehicle noise complaint.

Recommendation 3: Review and update vehicle noise information for future 311 customer service system.

The information gathered through complaint management provides useful information about noise annoyance and can contribute, when combined with others set of data collection, to improvements of the detection and analysis of hot spots.

Complaints provide updated data on vehicle noise issues and therefore can be very useful for SPS in its planning of enforcement initiatives. When a new vehicle noise complaint is entered in the complaint management system,

the complaint /noise source(s) (stunt driving, exhaust noise, etc.) should be properly classified to facilitate the complaint data analysis.

The City of Saskatoon is currently working on the development of a “311” customer service system that will be receiving the calls and emails and disseminating them to the appropriate service / division. The future system may include functionalities such as GIS mapping, a social media component that will allow to, respectively, map vehicle noise complaints location and analyze more easily vehicle noise concerns and complaints received from different channels. [32]

As an example, the City of Toronto highlights, on its webpage dedicated to noise - www.toronto.ca/noise, the use of vehicle noise complaints by the Toronto Police services to coordinate its enforcement initiatives (see Figure 8).

Online reporting tools with which residents can take and submit a photo or video recording of the vehicle noise source can facilitate and speed up the complaints collection and analysis and potential follow-up enforcement measures. As summarized in [29], many cities in the UK already use online reporting tools to collect noise complaints:

Many police forces and Local Authorities have online reporting tools that residents can use to complain about noise or report a crime. The Local Authorities who use an online reporting method tends to have a simple form for users to complete and submit electronically. Some Local Authorities direct residents to smartphone apps that can be used to collate evidence and to report noise problems, allowing the user to record and submit audio as part of their evidence.

Since web-based reporting tools are reliant on members of the public having access to the internet and a computer/smartphone, phone, a capacity for in-person complaint channels remains necessary.

The development and the use of an online reporting tool that allows real-time vehicle noise complaint reporting should be explored as 311 platform is developed.

Recommendation 4: Promote and advertise official 311 customer service system once operational.

5.4 Public awareness

Raising public awareness on vehicle noise should be one of the key components of the mitigation strategy. The public should be informed and awareness should be raised on the following topics:

- adverse health effects of vehicle noise;
- importance and the need for the vehicle noise mitigation strategy;
- general approach towards the vehicle noise problem;
- enforcement mechanisms;
- course of action undertaken and the expected results.

The main target audiences should be: 1. Citizens of Saskatoon (“general public”) and 2. Motorists and vehicle owners. The #KeepItDown campaign on Twitter and SPS appearances in the media should continue. Media should be made aware of any updates of the strategy and new enforcement campaigns.

Recommendation 5: Develop a communication and media strategy aimed at raising awareness on vehicle noise issues.

The only city-produced information on vehicle noise (SPS vehicle noise brochure) presents contradictory information with regards to the actual enforcement process and the use of the city noise bylaw. The part of the enforcement process that includes a vehicle inspection ticket, a letter from SGI and the risk of having the registration not renewed is missing from the brochure.

Recommendation 6: Review and update all existing city-produced public information on vehicle noise highlighting the legislation, enforcement processes and soft measures implemented by the City of Saskatoon.

There is no document or video that explains vehicle noise enforcement and gives examples of what an excessively noisy vehicle sounds like and how it can be perceived from indoors. Posters and flyers should be sent to key locations where drivers congregate (such as service centres, vehicle workshops and rest areas) and places that are conducive to creating empathy for residents impacted by vehicle noise.

Recommendation 7: Develop formal marketing material and video material for the city and SPS websites and share on social media.

One component of the current public awareness is the “noise clinics”. In the last few years, the noise clinics attracted a lot of motorcycles (with very few motorcycles that failed that test) [3] and generated good press coverage [33]. Considering that motorcycles are not the category of vehicle that constitutes the bulk of this problem [3] and that the noise level limit used during these clinics is not used to enforce vehicle noise in practice (section 3.3.1), the noise clinics may have limited value as they can be a source of confusion in the way the public understands the vehicle noise enforcement process.

Custom signage should be considered as part of the communication plan, to announce enforcement area(s) and to raise awareness and provide information. Edmonton pilot project in 2018 showed that measured noise levels should not be displayed [34], however, the use of responsive signage with explicit messages such as “You just woke up 200 people! Keep it quiet” could be an idea worth exploring (Figure 16).



Figure 16: Example of responsive anti-noise message road signs: “Bruit!” (Noise!) in Geneva, Switzerland (left) and “Trop bruyant” (Too noisy) in Saint-Lambert-des-Bois, France (right)

Recommendation 8: Develop and install responsive signage at critical locations.

A proper public awareness campaign may contribute to transforming behaviour, however, it has limitations, as mentioned in the “Practitioner Handbook for Local Noise Action Plans”, [35]:

influencing people’s behaviour is very difficult. Communication can make people aware of their behaviour, but generally it won’t change it. To change behaviour, sanctions or rewards are more appropriate means.

A public awareness campaign should make the public sympathetic to this cause. The use of data and statistics can be used to demonstrate risks and convince the audience. As an example, BruitParif, Paris noise observatory has created an animated noise map showing the evolution of the number of people awakened by a moped that drives in a neighborhood in Paris at night, with and without a proper muffler. [36] (Figure 17).

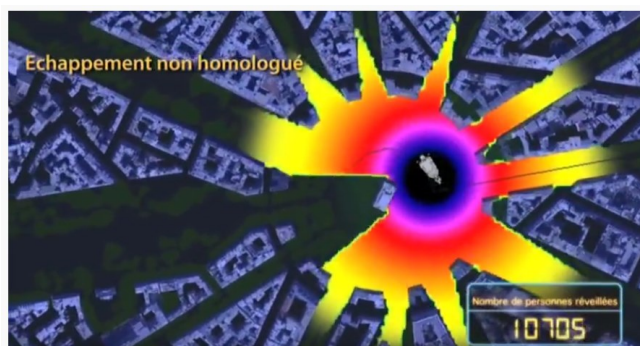


Figure 17: Screenshot of Video from BruitParif public awareness campaign on motorcycle noise [20]

Instead of using educational videos, the communication campaign should lean on short, attention-grabbing clips that quickly summarize the problem (e.g., Instagram reels and Tik-Tok trends). As an example, in 2019, Road Safety Scotland designed a road safety campaign with the slogan “drive like gran’s in the car.” and with videos in which a grandma challenging her grandson on his unsafe behaviour, whether it be speeding, driving on drugs, or getting distracted by friends in the car.

Recommendation 9: Develop short, attention-grabbing content that be used as ads on social media or as standalone campaigns.

5.5 Vehicle noise data collection and analysis

In addition to the information obtained from the public consultation, field data on vehicle noise should be collected and analyzed. The collection consists of measuring acoustical data and road traffic data that will be used as benchmark data.

The main goal of this strategy component is to assess the current situation and monitor the strategy progress. Two methodologies can be used:

- noise and road traffic measurements at roadside to detect and characterize excessively noisy vehicles “at the source”;
- noise measurements at residents’ property (inside or outside) to assess the impact of vehicle noise on residents’ health and welfare.

For a given location / area, the results of the measurements should aim to determine:

- what the main vehicle noise sources are (modified exhaust systems, street racing, stunting, etc.);
- number of excessively noisy cars and trucks travelling through an area;
- how many times and when the problematic events occur;
- relationship between acoustical metrics and health and welfare impacts (disturbance annoyance, sleep disturbance, dissatisfaction) reported by residents.

Technical details and guidance on vehicle noise data collection and analysis (including the acoustical metrics and statistical analysis to detect excessively noisy vehicles, measurement technology and measurement's consideration) are provided in Appendix A.

The recommended noise metrics and approaches (presented in Appendix B) can be measured and post-processed from data collected by commercially available noise and traffic monitoring systems. More advanced technologies that use spectral profile analysis and artificial intelligence algorithms to detect vehicle noise are currently under development but there is currently no solution dedicated to vehicle noise commercially available. At this stage, the development of an automated noise camera system funded by the City of Saskatoon is not recommended considering the current needs and the development costs that are difficult to estimate.

Recommendation 10: Use commercially available noise and traffic monitoring systems to collect and analyze vehicle noise-related acoustical data.

5.6 Enforcement

This section presents the study's main recommendations with regards to enforcement measures.

5.6.1 Noise Inspection notices prompted by pre-screened noise and road traffic monitoring data

The current enforcement approach is mostly based on roadside checks conducted by police officers; it is resource-consuming and has several limitations. An officer must be present to observe a vehicle being driven in contravention so enforcement is only effective while it is in place. Once the officer is no longer present, the problematic behaviour can return.

Resources and time allocated to enforce vehicle noise are proportionally small compared to other road safety issues. Furthermore, enforcement may require a mechanical inspection which builds upon officers' knowledge and expertise in mechanics and can be difficult to conduct at roadside.

Stationary noise level tests close to the exhaust pipes are not very efficient considering the enforcement resources that it requires and their limitations.

The review of the enforcement technologies showed that fully automated noise enforcement technologies are still under development and that, there is no off-the-shelf dedicated solutions available at the time of report writing. Also, as seen with Edmonton pilot projects, a hybrid enforcement approach where police officers would use their judgment (subjective assessment) together with noise levels measured in real time is not satisfactory (mostly because it is time consuming and costly).

The main objective is to optimize the vehicle noise enforcement efficiency and effectiveness by using information collected from the complaints management system, public consultation and field measurements campaigns. The following enforcement approach is suggested to overcome the current enforcement limitations and taking into

account the Saskatoon context. It consists of using pre-screened noise and road traffic data to identify excessively noisy vehicles and send an inspection notice to the vehicle owner requiring a vehicle noise inspection.

1. Audio recordings, noise levels, video, vehicle speeds, type of vehicles (car, motorcycles, trucks) are continuously measured and recorded by a monitoring station at roadside. Licence plate numbers are captured by an automated licence plate reader (ALPR) which is a high-speed, computer-controlled camera system). For privacy reasons, the monitoring system can be designed in such way that the licence plate number is measured but not continuously saved / recorded on the monitoring system.
2. Using proper metrics and site-dependent detection settings (Appendices A.1 and A.2), a combined analysis of both road traffic and noise data, allows, as an automatic pre-screening test, to detect probable excessively noisy vehicles;
3. When a vehicle pass-by is pre-screened as “excessively noisy”, the licence plate number, video and audio recordings associated with the vehicle pass-by are saved / recorded;
4. Subsequently and as part of the main screening process, pre-screened data can be analyzed and reviewed by City staff. It consists of viewing the video and listening to the audio recordings of the vehicle pass-by and assessing subjectively if this vehicle is excessively loud or not. The result of the licence plate number capture is also reviewed and analyzed;
5. If a vehicle pass-by is deemed excessively loud, an inspection notice is sent out to the vehicle owner requiring attendance at vehicle noise inspection in a dedicated vehicle noise inspection site (which is currently non-existent).

It is important to note that the full technical implementation of the measure would require the development of custom vehicle noise solutions (software and hardware) based on commercially available road traffic and noise monitoring systems. While technology using artificial intelligence may allow better detection of vehicle noise infractions, the use of a fully automated system as an enforcement tool is not yet realistically feasible.

Since the vehicle noise monitoring system does not generate charges, the procedure associated with the calibration / verification of vehicle noise monitoring stations should not be as tedious as the one required for speed radars under the automated speed enforcement program. Legal aspects and requirements of the suggested enforcement approach should be reviewed by the City solicitors.

The legislation that covers the vehicle noise inspection can be the provincial Vehicle Equipment Regulations or the City of Saskatoon's Noise Bylaw (on the basis of the article 5.3). The legislation and the methodology used should be reviewed considering the resources available within the city and at the provincial level (SGI).

The inspection testing should consist of the following:

- The exhaust system is examined visually for any defects, such as holes in the pipes;
- A subjective assessment should be made as to the effectiveness of the silencer in effectively reducing combustion noise (to a level considered to be average for the vehicle);
- Noise level limits (for motorcycles and using the city noise bylaw only).

The inspection testing should not be conducted at roadside. The implementation of dedicated test centre(s) / site(s) should be favoured: having vehicle drivers make an appointment, drive to a specific site and attend the inspection make the inspection process more formal. The use of dedicated test centre(s) / site(s) will also simplify the testing of motorcycles noise levels and will support and encourage the implementation of potential future noise-level based regulations.

Recommendation 11: Consider the development and implementation of new vehicle noise inspection procedures, potentially in collaboration with SGI, including sending vehicle noise inspection notices prompted by pre-screened noise and traffic monitoring data and the use of inspection sites dedicated to vehicle noise.

5.6.2 Enforcement parties

While SPS is the main enforcing agency, consideration should be given to include new stakeholders in the enforcement process in particular bylaw compliance officers.

Although they won't be able to conduct roadside enforcement or use the provincial vehicle noise regulations, city bylaw officers can give noise tickets (using the City of Saskatoon's Noise Bylaw) and, with proper training, provide in-house expertise in noise and contribute to the enforcement process with the following tasks:

- deployment, operation and maintenance of the monitoring systems;
- collection and analysis of the vehicle noise data.

In house capabilities to manage noise issues should be favoured as many noise-related items are currently contracted out due to lack of expertise. [37].

A noise control officer could be part of the bylaw compliance team. The knowledge and experience required for this position should include:

- experience investigating noise complaints and taking appropriate follow-up action;
- knowledge and experience with noise monitoring equipment;
- technical training and significant technical skills in data analysis;
- interpersonal, communication skills to manage relationships with other city stakeholders.

As an example, Toronto and Montreal have noise control officers. They are trained bylaw enforcement officers with expertise in noise measurements and noise control management. They are in charge of processing the noise complaints and enforcing some of the noise bylaw regulations. Even for bylaw articles for which sound level meters are not required, a noise control officer can also aggregate and analyze the noise complaints data and work with Police Service on mitigation and/or enforcement solutions. [5]

While the creation of a noise control officer position may be justified by the vehicle noise issues, it should be considered to expand the scope of work to others noise sources that generate complaints: such as industrial and commercial activities, outdoor HVAC equipment.

Recommendation 12: Dedicate internal resources to develop in-house noise expertise within the City of Saskatoon and in particular within the Bylaw Compliance team.

SGI is already involved in the City of Saskatoon enforcement strategy (section 3.3.1). The training and technical and regulatory support should be continued and developed.

The development of a common means to collect statistics on the number of SGI letters and vehicle inspections related to noise should be explored with SGI as it would be very relevant information on the enforcement progress.

5.7 Lobbying Provincial Government

SGL takes direction from the provincial government for modifications of the provincial regulations. Lobbying the provincial government is one of the components of the long-term mitigation strategy.

The current provincial fines are relatively small (the fine starts at \$115). Minimum fines for vehicle noise in cities such as Toronto, Regina, Vancouver, Victoria, Halifax range between \$200 and \$500.

Recommendation 13: Lobby the Minister responsible for SGL to implement higher vehicle noise fines and stronger inspection policies.

The Government of Ontario's new legislation Moving Ontarians More Safely Act includes tougher penalties for street racing and stunt driving infractions including:

- increasing length of driver's licence suspensions from seven to 14 days;
- increasing vehicle impoundment periods from seven to 30 days;
- escalating post-conviction licence suspensions, with up to a lifetime ban for a fourth infraction;
- lowering the threshold for laying street racing charges for those travelling 40 km/h or more above the posted limit on roads where the speed limit is less than 80 km/h.

These new penalties should be considered as a source of inspiration for lobbying the provincial government.

Recommendation 14: Lobby the Minister responsible for SGL to implement tougher penalties for street racing, stunt driving infractions.

5.8 Action plan

The development, implementation and management of the vehicle noise strategy relies on the development of an action plan and the allocation of staff resources. The recommended approach for the preparation of noise action plan is the nine-step process adapted from the Practitioner Handbook for Local Noise Action Plans, [35], illustrated in Figure 18.

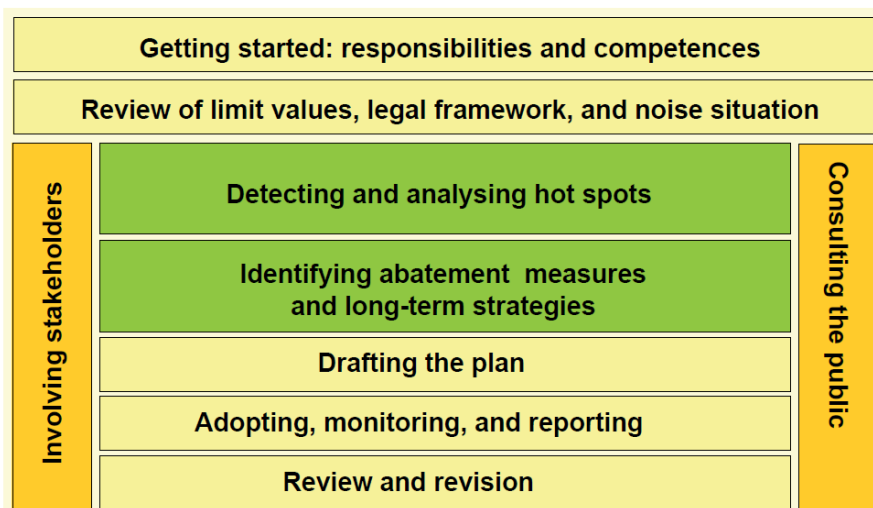


Figure 18: Noise mitigation strategy action planning nine-step process [35]

Each step of noise mitigation action plan does not need to be taken one after the other and it can be necessary to undertake several steps in parallel and /or to go back to a step that was assumed to be finished. Table 14 presents the status of each planning step (as of the date of this report).

Table 14: Mitigation strategy action planning steps objectives

Planning steps	Objectives	Status
Establish roles and responsibilities	<ul style="list-style-type: none"> to define a leader with sufficient capacities and competences to successfully set up the noise strategy; to involve all relevant stakeholders and make them contribute to the implementation of the plan; establish core competencies/expertise of each stakeholder. 	In progress To be completed
Review legal framework and current noise situation	<ul style="list-style-type: none"> take stock of the current context of the noise issue as a basis for any further action planning; identify which other strategies or tools could have a positive impact on the noise situation; 	Completed
Involving stakeholders	<ul style="list-style-type: none"> select the relevant stakeholders and make them aware of the noise issue; provide real participation opportunities and convince in the planning process; establish stakeholders' contribution. 	In progress To be completed
Consulting the public	<ul style="list-style-type: none"> consult the public on their noise perception, suggestions and priorities for noise mitigation measures while increasing public acceptance for necessary measures. 	Pending
Detecting and analyzing hot spots	<ul style="list-style-type: none"> define what should be considered as a vehicle noise hot spot; locate hot spots; make a thorough analysis of the situation. 	Initiated
Identifying noise mitigation measures and long-term strategies	<ul style="list-style-type: none"> define appropriate noise mitigation measures, including measures to tackle vehicle noise problems locally on a short-term basis as well as long-term strategies; set up a concrete work plan for the implementation of measures and strategies. 	In progress To be completed
Drafting the plan	<ul style="list-style-type: none"> summarize in a document the findings on the noise problems, measures to be taken, strategies to be implemented, responsibilities, allocated resources, and expected results. 	Pending
Adopting, monitoring, and reporting	<ul style="list-style-type: none"> adopt the plan at the political level, ensuring that there is enough support for its implementation; follow up the implementation, make sure that agreed measures are taken in time, and readjust the measures and/or the timetable whilst necessary to gain optimal results. 	Pending
Review and revision	<ul style="list-style-type: none"> keep the action plan up to date with regards to (major) changes in the noise situation. 	Pending

Considering the scope and range of tasks required, it is crucial to identify a staff position whose main task is to coordinate and support the development, implementation and management of the vehicle noise strategy. The first step should be an internal department to receive allocated resources for a noise specialist.

Recommendation 15: Create and sustain a staff position within the City of Saskatoon whose main task is to coordinate and support the development, implementation and management of the vehicle noise strategy.

This staff position would include the following tasks:

- establish stakeholders' roles and responsibilities;
- strategy planning and scheduling;
- funding and allocation of financial resources;
- stakeholders' engagement;
- coordination with potential external experts;
- manage and produce reports and other deliverables;
- review and monitor new approaches, strategies and technological development.

Representatives of the following organizations, departments or teams should be considered as stakeholders:

- City of Saskatoon Transportation;
- City of Saskatoon Community Services;
- City of Saskatoon Planning and Development;
- City of Saskatoon City Solicitor's Office;
- City of Saskatoon Community Standards;
- Saskatoon Police Service;
- Saskatchewan Government Insurance;
- Saskatchewan Health Authority.

Table 15 summarizes the recommended vehicle noise mitigation strategy with the expected outcomes and interactions between its main components. Table 16, Table 17, Table 18 present the short-term (less than a year), mid-term (between one year and two years) and long-term (beyond two years) action plan to implement the study's recommendations.

Table 15: Summary of the recommended vehicle noise mitigation strategy

Strategy component	Description	Outcomes
Complaint management	improve vehicle noise complaints management using the future 311 customer service system.	<ul style="list-style-type: none"> • facilitate the filing of complaints process; • identify hotspots; • improve planning of enforcement initiatives;
Public consultation	survey, questionnaire, focus groups, interviews to consult the public on the health and welfare impacts of vehicle noise (annoyance, sleep disturbance, dissatisfaction).	<ul style="list-style-type: none"> • inform and involve the public; • identify hotspots; • increase public acceptance; • improve planning of enforcement initiatives.
Vehicle noise data collection and analysis	short-term and long-term noise and traffic data measurement campaigns.	<ul style="list-style-type: none"> • assess the current situation and monitor the strategy progress with benchmark data; • identify hotspots; • develop in-house technical expertise; • improve planning of enforcement initiatives.
Enforcement	<ul style="list-style-type: none"> • Initiatives guided by information from the complaints management system, the public consultation and the field measurements campaigns; • vehicle noise inspections notices prompted by pre-screened noise and road traffic monitoring data; • responsive roadside enforcement, assisted by monitoring system(s) and citizen-sourced data. 	<ul style="list-style-type: none"> • optimize enforcement efficiency and effectiveness; • reduce the impacts of vehicle noise on the community.
Public Awareness	<ul style="list-style-type: none"> • communication and media campaign; • posters and flyers; • responsive road signage. 	<ul style="list-style-type: none"> • inform and raise awareness amongst citizens of saskatoon and motorists and vehicle owners; • increase public acceptance.

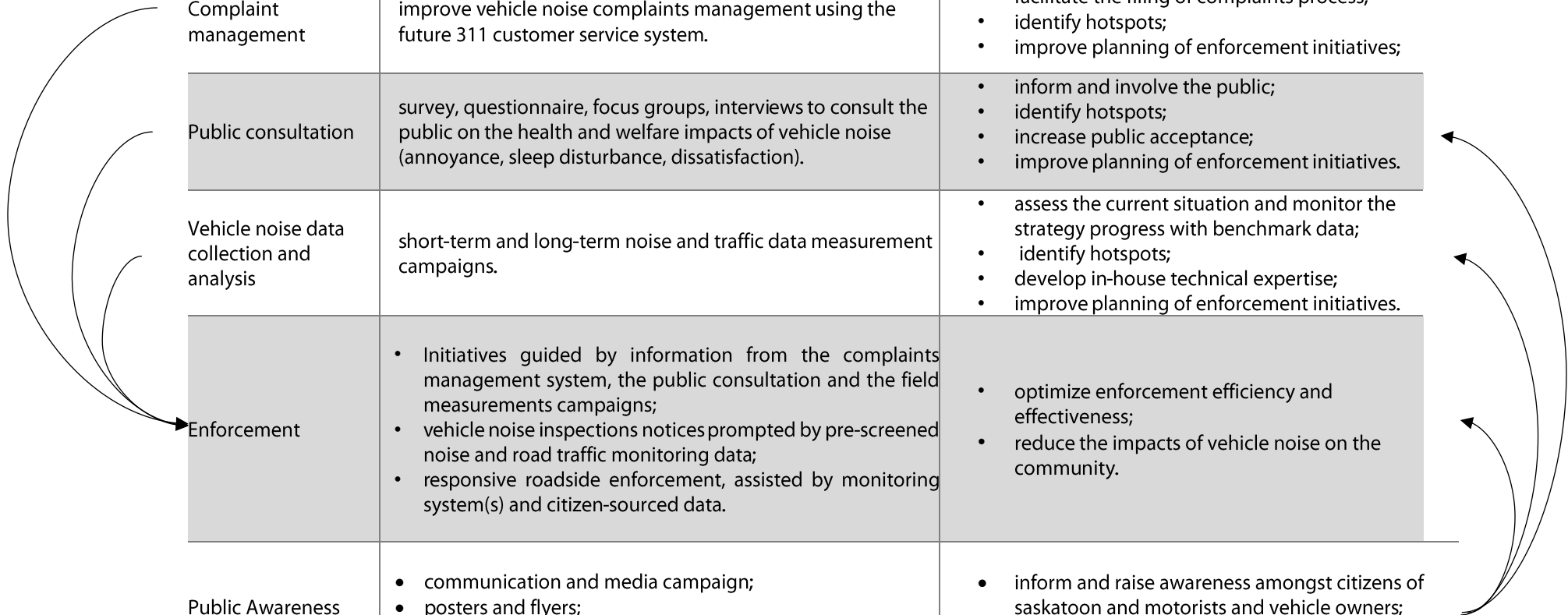


Table 16: Short term (less than a year) action plan

Strategy component	Description	Responsible	Financial impact
Public consultation	<ul style="list-style-type: none"> conduct the “conception & initiation” phase (project charter); conduct the “definition & planning” phase (scope, budget, schedule). 	City SHA, SPS External	TBD
Complaint management	<ul style="list-style-type: none"> develop a noise complaint management action plan; populate knowledge base with vehicle noise information. 	City SPS	TBD
Public awareness	<ul style="list-style-type: none"> develop a communication and media plan; conduct review of city-produced public information on vehicle noise audiovisual material for: <ul style="list-style-type: none"> the “conception & initiation” phase (project charter); the “definition & planning” phase (scope, budget, schedule). 	City and/or Public relations firm	TBD
Vehicle noise data	<p>10-day-long measurement campaign (data collection and analysis) at one test site (existing hotspots).</p> <p>Rental of 2 monitoring stations: one station at roadside measuring drive-by measurements (noise + road traffic), one station at a resident’s property measuring vehicle noise impacts (noise).</p> <p>Installation / Pick-up, technical support.</p> <ul style="list-style-type: none"> preliminary data collection and analysis (audio recordings, noise levels, video, vehicle speeds, type of vehicles); vehicle noise metric calculations, “average pass-by noise level versus vehicle’s speed” regression line, thresholds calculation; proof of feasibility study: statistical approach to detect excessively noisy vehicles, calibration settings; meetings, working sessions; report. 	Acoustical consultants Monitoring system vendor	\$ 25-30 k

Enforcement	<ul style="list-style-type: none"> • assess legal aspects and requirements of semi-automated enforcement approach using pre-screened noise and traffic data to identify excessively noisy vehicles and to send an inspection notice; • assess the development and feasibility of new vehicle noise inspection procedures; • assess resource allocation for in-house noise expertise. 	City SPS SGI	TBD
Lobbying	<ul style="list-style-type: none"> • prepare and submit a letter to the minister responsible for SGI lobbying for higher vehicle noise fines, stronger inspection policies and tougher penalties for street racing, stunt driving infractions. 	City SPS	TBD

Table 17: Mid term (between one year and two years) action plan

Strategy component	Description	Responsible	Cost
Public consultation	<ul style="list-style-type: none"> data collection and analysis (survey/questionnaire; focus groups); health and welfare impact assessment. 	City SHA, SPS External	TBD
Complaint management	<ul style="list-style-type: none"> implement the noise complaints management action plan; collect noise complaints and conduct vehicle noise complaints data analysis. 	City SPS	TBD
Public awareness	<ul style="list-style-type: none"> install responsive signage at critical locations (if any); audiovisual material (if any): footage collection; potential launch / execution of communication and media plan (TBD); #KeepItDown campaign on Twitter; City and SPS appearances in the media. 	City and/or Public relations firm	TBD
Vehicle noise data	<p>3-month-long measurement campaign (data collection and analysis) at three test sites</p> <p>Rental of 4 monitoring stations: one station at roadside measuring drive-by measurements (noise, road traffic, licence plates), three stations at a resident's property measuring vehicle noise impacts. Installation / Pick-up, technical support. Site selection based on Phase 1 data analysis and site visits: hotspots with 3 different areas/traffic configurations</p> <ul style="list-style-type: none"> long-term data collection and analysis (audio recordings, noise levels, video, vehicle speeds, type of vehicles) focussing on noise impact assessment; vehicle noise metric calculations, "average pass-by noise level versus vehicle's speed" regression line, thresholds calculation; proof of feasibility study: semi-automated enforcement using automated plate reader (calibration); meetings, working sessions; report; health and welfare impact assessment (partially). 	<p>City SPS SGI SHA</p> <p>Acoustical consultants Monitoring system vendor</p>	\$ 40-60 k

Enforcement	<ul style="list-style-type: none"> proof of feasibility study: semi-automated enforcement using automated plate reader; meetings, working sessions. 	City SPS SGI	TBD
Lobbying	<ul style="list-style-type: none"> follow-up on the letter to the Minister responsible for SGI; #KeepItDown campaign on Twitter; City and SPS appearances in the media. 	City SPS	TBD

Table 18: Long term (beyond two years) action plan

Strategy component	Description	Responsible	Cost
Public consultation	<ul style="list-style-type: none"> annual health and welfare impact assessment (based on complaints and noise monitoring data analysis). 	City SHA, SPS	TBD
Complaint management	<ul style="list-style-type: none"> annual vehicle noise complaints data analysis; assess the development and implementation of online reporting tool. 	City SPS	TBD
Public awareness	<ul style="list-style-type: none"> performance review of communication and media plan (TBD); #KeepItDown campaign on Twitter; City and SPS appearances in the media. 	City and/or Public relations firm	TBD
Vehicle noise data	<p>1. Purchase of permanent vehicle noise monitoring station(s) – number of stations: TBD</p> <p>Cost per station strongly depends on the number of stations purchased and software functionalities: between \$10k and \$15k (+ monthly fees). Cost includes maintenance costs (annual calibration of the microphones / sound level meters / acoustic calibrators), software subscription fees, technical support.</p> <p>2. Development of a custom vehicle noise solution (software and hardware): > 75k\$</p> <ul style="list-style-type: none"> development of custom “vehicle noise” functionalities for impact assessment and enforcement: <ul style="list-style-type: none"> semi-automated vehicle noise enforcement tool using automated plate reader; Site-specific calibration process; Data management and analysis tools. <p>3. Proof of feasibility study: “noise camera”, fully automated detection system using artificial intelligence algorithms (>\$ 40k)</p>	City SPS Monitoring system vendor	TBD

Enforcement	<ul style="list-style-type: none"> proof of feasibility study: semi-automated enforcement using automated plate reader; meetings, working sessions. 	City SPS SGI	TBD
Lobbying	<ul style="list-style-type: none"> follow-up on the letter to the Minister responsible for SGI; #KeepItDown campaign on Twitter; City and SPS appearances in the media. 	City SPS	TBD

6 List of principles and recommendations

Principle 1: The strategy's main goal should be with a public health perspective, focusing on reducing the impacts of vehicle noise on the community with health and welfare impacts as one of the main success indicators.

Principle 2: Design and implement the vehicle noise strategy for the entire city.

Principle 3: Develop a data collection and analysis plan with acoustical data, public feedback and complaints data.

Recommendation 1: Develop and carry out a multifaceted public consultation strategy to solicit input from the public on the vehicle noise issue.

Recommendation 2: Establish and implement an improved complaints management system for vehicle noise.

Recommendation 3: Review and update vehicle noise information for future 311 customer service system.

Recommendation 4: Promote and advertise official 311 customer service system once operational.

Recommendation 5: Develop a communication and media strategy aimed at raising awareness on vehicle noise issues.

Recommendation 6: Review and update all existing city-produced public information on vehicle noise highlighting the legislation, enforcement processes and soft measures implemented by the City of Saskatoon.

Recommendation 7: Develop formal marketing material and video material for the city and SPS websites and share on social media.

Recommendation 8: Develop and install responsive signage at critical locations.

Recommendation 9: Develop short, attention-grabbing content that be used as ads on social media or as standalone campaigns.

Recommendation 10: Use commercially available noise and traffic monitoring systems to collect and analyze vehicle noise-related acoustical data.

Recommendation 11: Consider the development and implementation of new vehicle noise inspection procedures, potentially in collaboration with SGI, including sending vehicle noise inspection notices prompted by pre-screened noise and traffic monitoring data and the use of inspection sites dedicated to vehicle noise.

Recommendation 12: Dedicate internal resources to develop in-house noise expertise within the City of Saskatoon and in particular within the Bylaw Compliance team.

Recommendation 13: Lobby the Minister responsible for SGI to implement higher vehicle noise fines and stronger inspection policies.

Recommendation 14: Lobby the Minister responsible for SGI to implement tougher penalties for street racing, stunt driving infractions.

Recommendation 15: Create and sustain a staff position within the City of Saskatoon whose main task is to coordinate and support the development, implementation and management of the vehicle noise strategy.

7 Conclusion

Soft dB has undertaken a vehicle noise mitigation study for the City of Saskatoon to research, review, engage stakeholders and recommend suitable mitigation measures.

The objectives of the study were to identify Saskatoon's current context, identify best practices (in terms of regulation, enforcement approach, mitigation strategy, public awareness), undertake stakeholders' engagement; elaborate and assess guiding principles and recommend vehicle noise mitigation measures.

The analysis of the Saskatoon context was conducted based on existing literature and documentation provided by the City of Saskatoon and meetings from the stakeholders' engagement process. The stakeholders were the Saskatoon Police Service (SPS), Saskatchewan Government Insurance (SGI), Saskatchewan Health Authority (SHA), Saskatoon Traffic Safety Prosecutions and several departments of the City of Saskatoon.

Several issues and challenges have been identified through the Saskatoon context analysis. Issues and challenges common to any city include the limitations of complaint-based-only approaches, the use of subjective criteria to assess compliance, the resource limitations associated with manned enforcement and the regulatory and enforcement limitations associated with aftermarket mufflers and "Original Equipment Manufacturer" (OEM) exhaust modes. Issues and challenges specific to Saskatoon include the lack of vehicle noise data to obtain a complete picture of the situation, current noise complaints management, resource limitations of the SGI inspection program and limited and outdated city-produced information on vehicle noise.

A review of 16 municipal and 6 provincial regulations was conducted. No particular municipal or provincial regulation particularly stands out. Saskatoon legislation has a lot of similarities with the regulations under review and has no striking deficiencies.

A vehicle noise mitigation strategy includes any type of measures that might reduce the impact caused by excessively noisy vehicles. While law enforcement initiatives are usually at the core of mitigation strategies, soft measures such as awareness campaigns, lobbying actions, regulation updates, public consultation and noise checking events have been implemented to encourage and promote behavioural change without penalizing offenders. The most relevant vehicle noise mitigation initiatives conducted by Canadian cities in the last 10 years are summarized and presented. Edmonton and Calgary stand out as having conducted pilot projects that include the development and/or trial of technology dedicated to vehicle noise enforcement.

Press coverage on vehicle noise issues and mitigation initiatives were analyzed for 20 Canadian cities but no positive press coverage on vehicle noise initiatives has been found. The lack of documentation around successful initiatives highlights the complexity of mitigating vehicle noise issues.

The use of technologies to enforce vehicle noise is discussed. Class 1 and class 2 sound level meters are currently used to enforce noise-level based regulations. Noise and road monitoring technologies have been developed for the pilot projects in Calgary and Edmonton. Recent examples of noise camera systems are described. While several noise camera systems are currently being tested, there is, at the time of drafting this report, no commercially available solution dedicated to vehicle noise.

Building on the learning from the context analysis and the review of vehicle noise regulations and mitigation strategies, three guiding principles and 16 recommendations are presented. Guiding principles promote a multifaceted approach with enforcement, education, and public awareness that focuses on reducing the impacts of vehicle noise on the community through a public health lens.

The collection and analysis of quantitative and qualitative data on vehicle noise (acoustical data, public feedback) is recommended to effectively measure and predict community reactions to noise and improve guidance on enforcement measures. An improved complaints management system using the future 311 customer service system should be promoted by the city. Recommendations on a public awareness campaign are provided including on possible content for marketing and communications and responsive signage.

Technical knowledge is provided on metrics, approaches and technology to collect and analyze vehicle noise-related acoustical data.

Two enforcement approaches are suggested to overcome the current enforcement limitations and improve the enforcement efficiency and effectiveness. The first approach consists of using pre-screened noise and road traffic data to identify excessively noisy vehicles and send an inspection notice to the vehicle owner mandating attendance at a vehicle noise inspection site. For the second approach, it is suggested to use monitoring systems and citizen-sourced data to increase the likelihood of “catching” excessively noisy vehicles in the act and to document and share information on these vehicles in order to improve planning of enforcement initiatives.

While SPS should remain the main enforcing agency, it is suggested to dedicate internal resources to develop in-house noise expertise within the City of Saskatoon and sustain a staff position whose main task is to coordinate and support the development, implementation and management of the vehicle noise strategy.

Lobbying actions directed at the Minister responsible for SGI are suggested to implement higher vehicle noise fines, stronger inspection policies and tougher penalties for street racing and stunt driving infractions.

Finally, the main components of the suggested strategy and their expected outcomes are summarized, a nine-step approach to develop and implement strategy is detailed with short-term (less than a year), mid-term (between one year and two years) and long-term (beyond two years) action plans.

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Appendix A: Technical guidance on vehicle noise data collection and analysis

This section explains technical solutions and approaches to measure and analyze vehicle noise data including:

- the acoustical metrics and statistical analysis to detect excessively noisy vehicle;
- the measurement technology;
- measurement's methodology.

As already mentioned, there are two measurement methodologies:

- noise and road traffic measurements at roadside to detect and characterize “at the source” excessively noisy vehicles;
- noise measurements at residents’ property (inside or outside) to assess the impact of vehicle noise on residents’ health and welfare.

For “drive-by” noise measurements at roadside, the standard “ISO 11819-1:1997 Acoustics - Measurement of the influence of road surfaces on traffic noise - Part 1: Statistical Pass-By method” (which is usually used for measuring vehicle pass-by's tire-road noise) provides a relevant reference methodology. The measurement methodology includes measuring the noise levels and speed of individual vehicles passing a fixed point on a road and processing the data after the testing.

A.1 Noise metrics

The use of dedicated acoustical metrics is crucial to be able to correctly:

- distinguish vehicle pass-by from the background noise;
- detect and analyze each vehicle pass-by individually;
- detect the presence of excessively noisy vehicles;
- assess the impact on residents (risk of sleep disturbance or annoyance).

A very common metric for community noise assessment is *A-weighted* equivalent sound pressure level in dB (LAeq) measured on a daily basis and “energy-averaged”ⁱⁱ over several periods (8, 16, 24 hours). However, in the case of vehicle noise, averaged noise levels do not allow to accurately quantify the noise peaks caused by excessively noisy vehicles. Indeed, the noise generated by excessively noisy individual vehicles passing by is not continuous; each vehicle that can be heard in the traffic stream is seen as an intermittent single noise event and there is a consensus (among several studies on sleep disturbance effects of aircrafts and trains) that the maximum noise level of single noise events and the number of noise events are better predictors of noise-induced sleep disturbances than energy-averaged metrics (LAeq).

In other words, sleep disturbance from intermittent noise events will increase with the maximum noise level and not with the equivalent “averaged” noise level. Even if the equivalent background noise level is low, a small number of noise events (with a high maximum sound pressure level) will affect sleep. [38]

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Equivalent sound pressure level is a continuous sound pressure level (SPL) of noise averaged over time which contains the same amount of energy as that generated by the actual and varying sound levels being measured. This is not an arithmetic average.

During the time a vehicle passes, the noise level starts at the ambient or background noise level, rises to the maximum level as the vehicle passes closer to the observer and returns to the background level as the vehicle recedes into the distance. The background noise includes all noise sources except the noise of the vehicle.

The main metric to measure maximum sound level is L_{Amax} which is the highest sound level measured during a short period ⁱⁱⁱ.

A threshold L_{Amax} level allows to differentiate the vehicle noise from the ambient noise. The event threshold level value will be dependent on the site set up and should be set depending on whether the measurements are indoor or outdoor and on the contribution of other noise sources. As a reference, noise-induced awakenings have been observed at individual L_{Amax} exposures of 45 dB or less. [38], in practice, a higher L_{Amax} threshold level is expected, even for indoor measurements.

L_{Amax} describes the maximum instantaneous level of a noise event but does not provide information about cumulative sound energy of the vehicle passing by. To address this limitation, the Sound Exposure Level (SEL) metric should be also calculated and used to complement the L_{Amax} to compare vehicle noise events.

SEL reflects the total sound energy produced during an event, from the time when the sound level first exceeds the threshold to the time when it again drops below the threshold. SEL value is normalized to one second, allowing comparison of individual vehicle noise events with very different duration. As an alternative to the SEL metric, an equivalent continuous sound pressure level L_{Aeq} calculated for each pass-by (over the time of the vehicle passing by) and referred to as L_{Aeq} pass-by can also be used.

In addition to measuring the noise levels, it is also necessary to count the number of excessively noisy vehicles passing by. This number can be calculated as the number of vehicles passing by, exceeding a certain L_{Amax} level (commonly indicated by NA_{xx} ; NA_{70} is the number of events higher than 70 dB). The combined duration and average duration of the events exceeding a certain L_{Amax} level should also be calculated.

Statistical noise levels (sometimes called percentiles) L_n values should be used to assess the measured noise level fluctuation over time and the level associated with the noisiest events. The n-percent exceeded level, L_n , is the sound pressure level exceeded for n percent of the time. In other words, for n percent of the time, the fluctuating sound pressure levels are higher than the L_n level. In community noise assessment, the most commonly used L_n values are the L_{10} and the L_{90} . L_{10} is the level exceeded for 10% of the time (for 10% of the time, the sound or noise has a sound pressure level above L_{10}). L_{10} is often used to assess noise peaks while L_{90} which is L_{90} is the level exceeded for 90% of the time, is often used to quantify the background noise levels. In the case of the vehicle noise assessment, excessively noisy vehicle levels can be quantified using L_{10} or even L_1 levels.

Figure 19 illustrates vehicle noise levels measured at roadside, vehicle classification, event threshold, L_{Amax} and SEL metrics. Table 18 summarizes the recommended noise metrics and indicators to assess vehicle noise.

ⁱⁱⁱ As measured with sound level meters, the time constant of the L_{Amax} measure may either be Fast (125 ms), Slow (1 s) or Impulsive (35 ms)

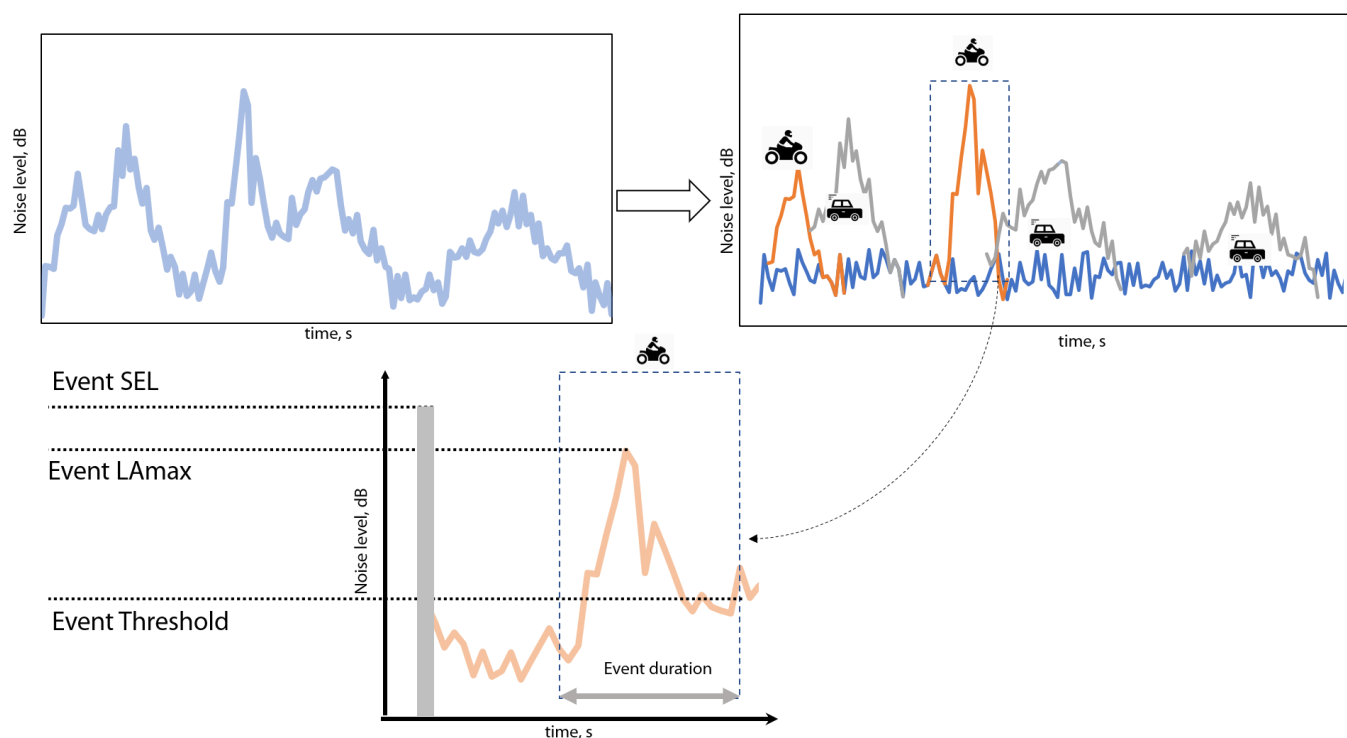


Figure 19: Illustration of noise levels generated by vehicles at roadside, vehicle classification and noise metrics for event detection

One approach to identify individual noise events in a measurement found in the literature [39] is to split the measurement period into short intervals and identify the LAmax level in each. The length of time interval will significantly affect the number of noise events identified, a duration between 1 and 3 minutes is suggested, corresponding to between 160 and 480 maximum noise levels over the course of an 8-hour night-time period.

Table 19: Recommended noise metrics and indicators to assess vehicle noise impact

Metrics / Indicators	Assessed characteristics
LAmax	Maximum sound level
SEL	Total sound energy produced by one vehicle passing by, normalized to one second
LAeq « pass-by » dBA	Total sound energy produced by one vehicle passing by
N _{Axx}	Number of vehicles passing by, exceeding a certain LAmax level xx
T _{Axx}	Average duration of the events exceeding a certain LAmax level xx
ΣT _{Axx}	Combined duration of the events exceeding a certain LAmax level xx
L ₉₀	Background noise
L ₁₀	Noise peaks
L ₁	Noise peaks

A.2 Excessively noisy vehicle detection

To detect if a noise peak is indeed generated with an excessively noisy vehicle, one of the simplest and most accurate approaches (yet very time-consuming) is to listen to the audio recording and compare the noise of each individual pass-by with the synchronized and associated with the noise level readings.

In order to avoid having to listen to each audio recording, several types of statistical analysis can be used. Our recommended approach (inspired by the Transport Research Laboratory research projects in the UK, [40], [41]) is to compare the maximum noise level of each vehicle pass-by with an average “pass-by” noise level for the same pass-by speed. This approach requires to collect for each vehicle passing-by: its speed, its vehicle category (cars or motorcycles) and the maximum noise level, L_{Amax} associated with its pass-by. It includes 2 components:

1. Calibration
 - a. The calibration first step consists of a measurement campaign when the maximum noise level (L_{Amax}), the vehicle category and the speed of each individual vehicle pass-bys are measured during several hours. Each individual vehicle pass-by can be detected manually or using statistical methods;
 - b. Data of excessively noisy vehicles are excluded and, for each vehicle category (cars and motorcycles) an average maximum noise level is calculated;
 - c. For each vehicle category, a regression line between average pass-by noise level and speed is calculated.
2. Detection
 - a. The maximum noise level (L_{Amax}), the vehicle category and the speed of each individual vehicle under evaluation are measured;
 - b. for the vehicle under evaluation speed, the vehicle under evaluation maximum noise level is compared with the average pass-by noise level of the regression line;
 - c. Motor vehicles with noise levels in excess of one standard deviation from the average pass-by noise level for the same pass-by speed can be identified as excessively noisy vehicles.

Figure 20 illustrates the statistical approach using “car average pass-by” Vs “Speed regression line” to detect excessively noisy vehicle at roadside.

Based on [40], the maximum noise level of a passing vehicle is correlated to the logarithm of the vehicle’s speed (in km/h). As an example, for the measurements conducted during Transport Research Laboratory research project [40], [41]), the maximum levels of excessively noisy cars were at least 3.1 dB L_{Amax} higher than with average noise levels and the loudest vehicles maximum levels were 6 - 8 dB higher than the site average maximum pass-by measured noise level.

Listening to the audio recording of the vehicle passing-by will allow to detect “by ear” the presence of a modified exhaust system and potentially differentiate between exhaust noise and noisy driving styles.

Field measurements [40] showed that modified or defective exhaust system generates low frequencies with harmonics at 100 Hz and 200 Hz. Modified exhaust systems can also be identified with a spectral analysis spectral of pass-by noise using third octave band spectral analysis and by comparing the low frequency component of noise of vehicles with and without modified exhaust system.

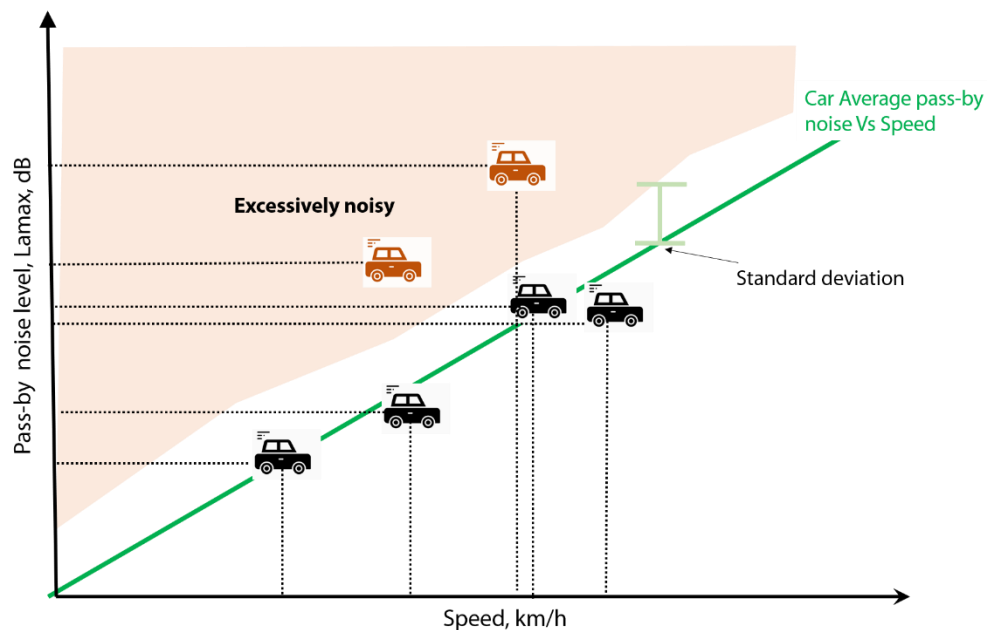


Figure 20: Illustration of the statistical approach using “car average pass-by” Vs Speed regression line for excessively noisy vehicle detection at roadside

A.3 Technology

Figure 21 illustrates the location and main features of the two types of monitoring systems required to assess vehicle noise.

Existing monitoring systems are flexible and can be used for a range of site conditions. Off-site systems can include solar panels and /or batteries. They are relatively easy to set up and relocate. A low level of maintenance is expected and no significant user input is required to operate them.

Outdoor noise monitoring systems include a sound level meter (enclosed in a weatherproof enclosure) and an outdoor measurement microphone with a windscreen (Figure 22).

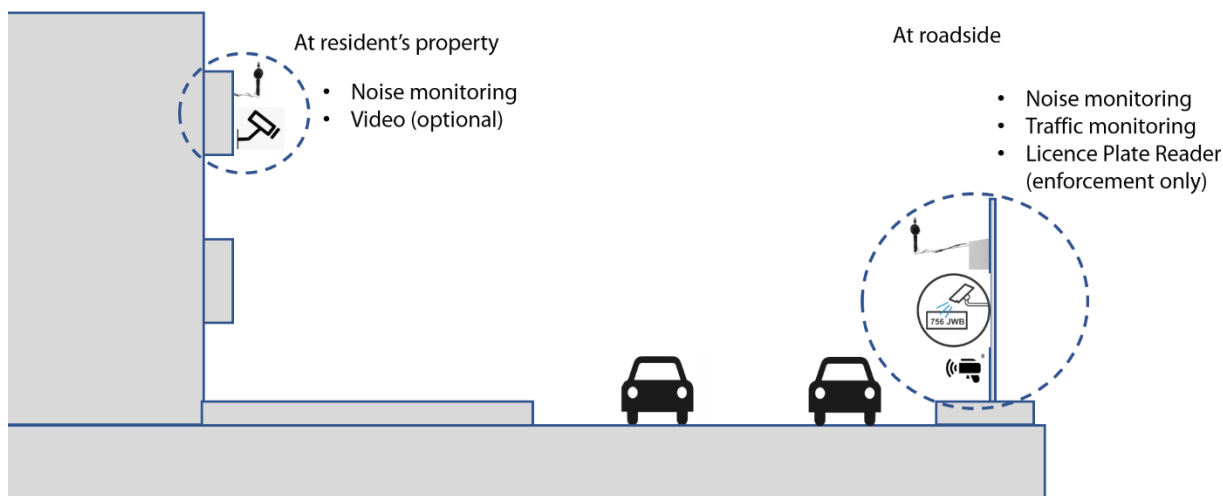


Figure 21: Location and main features of the two types of monitoring systems required to assess vehicle noise

Analysis and calculations functionalities of these monitoring system will provide “standard” acoustical metrics. Statistical approaches detailed in section A.2 to distinguish vehicle pass-by from the background noise or detect the presence of excessively noisy vehicles require additional data analysis and user intervention. If needed, an “online” feature will allow to automatically upload measurements to the cloud (using a mobile phone network) and provide a 24/7 remote access to the measurements and recordings using a web-based interface (Figure 22).

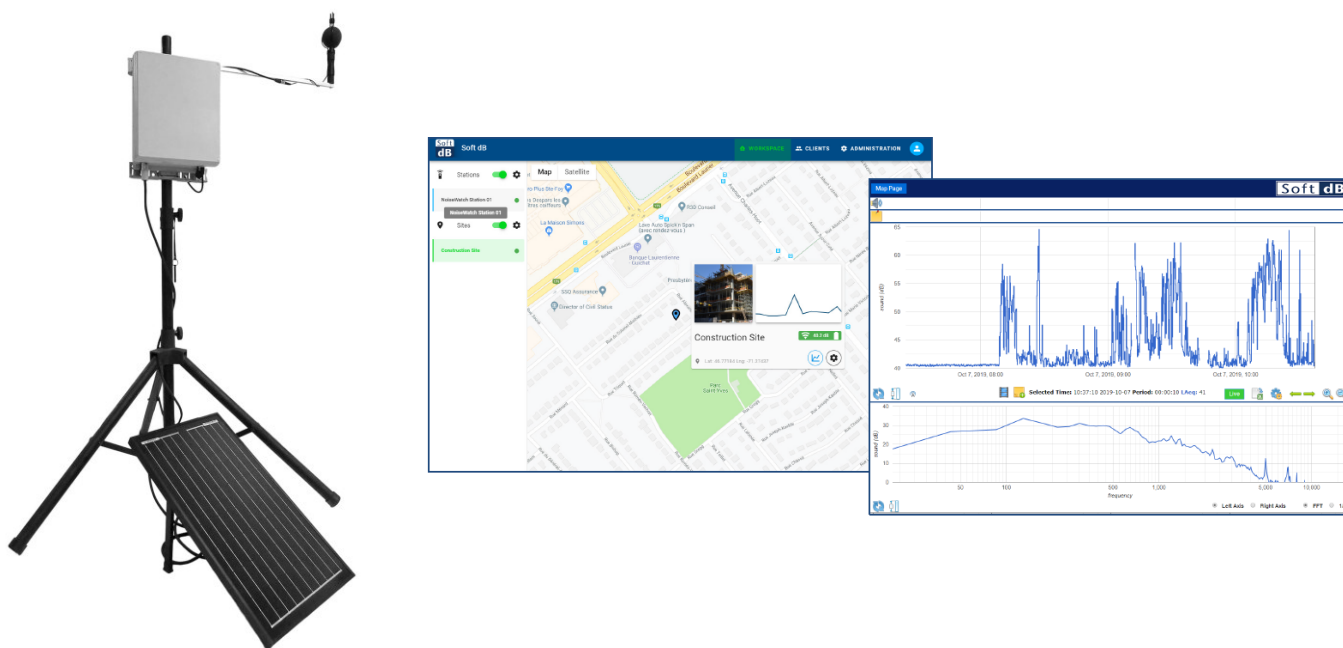


Figure 22: Example of an autonomous noise monitoring system with its web-based interface (Soft dB Noise Watch)

Technical specifications of the monitoring station used at residents' property should include:

- sound level meter that complies to IEC 61672/ANSI S1.4 Class 1;
- microphone environmental protection kit (wind screen, bird spikes);
- calculation of Leq, Lmax, Lmin, Lpeak, and SEL metrics in A, C, and Z weightings;
- percentiles (LN%) for selected weighting (A, C or Z): L1, L10, L90;
- 1/1 Octave, 1/3 Octave and FFT;
- audio recordings;
- audio events detection feature (event trigger);
- data export feature for acoustical data processing and analysis;
- measurements and recordings downloads;
- data visualization and custom data reports.

The recommended measurement analysis to detect excessively noisy vehicles in motion using relationship between an average maximum noise level and vehicle speed requires to measure the vehicle speed and to identify if the vehicle is a car or a motorcycle. The monitoring station at roadside requires the use of a road traffic monitoring sensor/device that measures vehicle speed and classify vehicle types.

Several noise monitoring station solutions have an integrated road traffic monitoring sensor as an option. A standalone road traffic monitoring sensor can also be used in combination with a noise monitoring station but the approach requires further actions to cross-analyze noise and traffic data. Depending on the duration of the measurement campaigns, the station location, and the ability to access it and download the data, the following "online" functionalities may be very useful but not necessary:

- alerts for monitoring stations warnings (low battery, offline, etc.);
- exceedance alerts (SMS and emails);
- real-time records uploads;
- remote measurements settings;
- remote measurement visualization and analysis;
- custom access pages for measurement visualization and analysis (for example: one access page for residents and one access page for SPS and the City of Saskatoon).

A.4 Measurements methodology

Monitoring station locations should be safe and relatively easy to access. Electricity to power the monitoring stations would be required if no solar panels are used. The location of the monitoring station compared to the road may vary subject to the road's design and site constraints.

For the roadside monitoring stations, the microphone should be conducted 1.5 m above the ground and at least 1-2 meters from any reflective surface to avoid reflections that could contaminate readings.

If operated by the City of Saskatoon, staff training will be required to configure and use the interface, to install and calibrate the system. The sound level meter should be field-calibrated at the time of the measurements (before beginning, during prolonged sessions, and after completion of the measurements) using a sound level calibrator.

A monitoring system should measure and detect excessively noisy vehicles regardless of the weather conditions. Wind and traffic on wet roads can increase ambient noise and affect vehicle noise detection threshold. However, measurements should be conducted even during precipitation or when the ground is wet. Weather conditions

(temperature, relative humidity, wind speeds, wind direction, rain, snow) should be recorded and analyzed together with the acoustical data.

For measurements at the resident's property and depending on the distance from the road (distances of 40 m and more), temperature inversion can result in a significant noise level increases compared to neutral atmospheric conditions.

Attention should be paid to ensure that the measurement conditions are within the tolerances of the instrumentation (e.g., for operating temperatures typically -15° to 40° unless protected).