# **Regulatory Mitigation of the Adverse Environmental Effects of Urban Blasting**

by

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# Abstract

Blasting techniques and protective measures exist that can mitigate risks associated with flyrock and the nuisance of vibration, and overpressure. However, these are often misused or not used because there are no prescriptive regulatory requirements and typically, urban blasting guidelines do not exist. The relationship between the increasingly negative publicity that the urban blasting industry receives and the existing state of regulatory control on blasting in urban environments is presented.

Specific research points include:

- Incidents of flyrock, vibration and overpressure related to blasting operations in urban environments were investigated across Canada but with a focus in the province of British Columbia.
- 2. A comparison and evaluation of blasting regulatory control in Canada, United States and Australia are presented.
- 3. An analysis of incidents and complaints, complemented with the approaches used to regulate blasting was performed.
- 4. Provincial and municipal regulators, blasting contractors, and blasting consultants were interviewed to seek advice on practical amendments to Canadian regulations to mitigate the adverse environmental effects of urban blasting.

At the provincial level, it is recommended that an amendment to WorkSafeBC's Blasting Regulations Part 21.66 (1) to hold the blasting company, in addition to the blaster, responsible for flyrock incidents will reduce incidents.

At the municipal level, it is suggested that a proposed harmonized blasting bylaw, that includes an education plan in the form of an informative pamphlet, will reduce the number of vibration, and overpressure complaints. This blasting bylaw coupled with delivery of the pamphlet should minimize (i) risk to a municipality, (ii) cost and time commitment to a municipality, (iii) complaints made by concerned residents, and (iv) adverse effects on blaster productivity.

# Preface

Sections of Chapter 3 that summarize the gaps in blasting regulations in the province of BC has been published. Loeb J. & Tannant D.D. 2012. Urban blasting – gaps in regulatory control in British Columbia. Proc. 38th Annual Conf. on Blasting Technique – International Society of Explosives Engineers, Nashville.

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# **1** Introduction

Many construction projects throughout the province of British Columbia require significant rock excavation. Whether it is a cut for roads or mass transit systems, tunnels, deep and shallow foundation excavations, or trenching for underground services, blasting is a historically proven technique for precision rock mass removal (ISEE, 2011). This unique trade causes inevitable adverse environmental effects including: vibration, noise, dust, fumes and if carried out improperly – flying debris.

## 1.1 Rationale and Objectives

The blasting industry in BC is receiving increasingly negative media attention, driven by complaints of vibration, overpressure and flyrock made by neighbours of blast sites. There is not an absence of science and trained blasters are aware of the procedures that minimize the effects of vibration, overpressure and the likelihood of flyrock. However, an absence of prescriptive regulations allows some blasters to prioritize cost and schedule over the safety and consideration of the surrounding public.

The main objective of this research is to minimize the number of flyrock incidents, and complaints of vibration and noise resulting from urban blasting through regulatory amendments and development. The specific research tasks are fivefold.

- 1. Investigate incidents of flyrock, vibration and overpressure related to blasting operations in urban environments across Canada but with a focus in the province of British Columbia.
- 2. Compare and evaluate blasting regulatory control in Canada, United States and Australia.
- 3. Perform a comparative analysis of incidents and complaints, complemented with the approaches used to regulate blasting.
- 4. Interview provincial and municipal regulators, blasting contractors, and blasting consultants to seek advice on practical amendments to Canadian regulations to mitigate the adverse environmental effects of urban blasting.

5. Provide recommendations of amendments to existing regulations or the development of new regulations to control flyrock, vibration and overpressure under the appropriate governing authority.

# 1.2 Thesis Methodology

The research is conducted with a somewhat linear methodology, with Chapter 4 on Flyrock and Chapter 5 on Vibration and Overpressure being independent of one another. An organizational structure of the major topics of the thesis is provided in Figure 1.



Figure 1: Thesis structure

A brief description of the methodology used for each major aspect of the thesis is described below. Each number corresponds to the thesis chapters, as shown in Figure 1.

- 3. Blasting regulations at all relevant national, provincial/state, and municipal levels in Canada, United States and Australia were thoroughly investigated by accessing the online regulations in their respective jurisdictions.
- 4. All *flyrock* incident reports available within the past ten years from WorkSafeBC's Freedom of Information office in Richmond, BC and other equivalent provincial regulators were gathered. The underlying causes of flyrock are identified and a comparison of incidents and the discrepancy in provincial regulations between the provinces are performed. From this analysis, an appropriate governing body to regulate the issue was identified. Finally, through an iterative approach, findings were presented to blasting contractors, consultants, and regulating authorities and amendments were made until all parties had overall satisfaction with a finalized regulation.
- 5. Data for complaints of *vibration* and *overpressure*, that have no formal reporting process, were collected through interviews with municipal engineers across British Columbia. The underlying causes of complaints of vibration and overpressure were documented and compared with the existing blasting regulations within each municipality. From this analysis, an appropriate governing body to regulate the issues was identified. Findings from this analysis were presented to blasting contractors, regulators and consultants across the country in order to ensure that regulations minimize complaints, but also minimize the effect on blaster productivity. This iterative approach aided the development of set of regulations that all stakeholders were satisfied with.

# 2 Background

The prerequisite information required for this thesis is divided into three subcategories:

- *Description of blasting* a brief synopsis of how blasting is done, including its adverse environmental effects.
- *Blasting in the news* a description of the negative publicity that the blasting industry is receiving which led to commencement of this thesis topic.
- *Difficulties regulating the issues* an overview of the problem that BC municipalities are facing and an insight into the service this thesis will provide.

# 2.1 Blasting

## 2.1.1 Overview of blasting

Rock blasting is the controlled practice of breaking rock with explosives (Persson et al. 1994). Precision blast design is the optimization of many parameters, which can be initially difficult as they depend on site geology (ISEE, 2011). For example, suppose a receding a rock face is being blasted to make way for a new highway. Below is a schematic of a typical blast and description of blast design parameters.



Figure 2: Typical blast design

Each borehole is typically tied-in using the non-electric system (ISEE, 2011). A thin tube containing a small amount of explosive material detonates the loaded holes in the sequence

shown in Figure 2, where number one denotes the point of initiation and number seven is the last hole detonated.

In order to safely match the energy of explosives with the strength of the rock, there are many design parameters that must be optimized:

- *Burden* (*B*) Shortest distance from an explosive charge to the nearest face (ISEE, 2011).
- *Spacing* (*S*) Distance between boreholes that are loaded with explosives. It is measured parallel to the free face and perpendicular to the burden (ISEE, 2011)
- *Face* Rock faces that border on relief (ISEE, 2011).
- Delay Sequence the numbers in Figure 2 denote the sequence in which the holes are detonated. In urban blasting, there is a minimum of 8 millisecond delay between blast holes and a typical delay is 25 milliseconds (ISEE, 2011). In Figure 2, for example, the blast would take 48 milliseconds to full detonate all holes. Delay sequences, designed by professional blasters, are one effect means of vibration and overpressure reduction.
- *Stemming* An inert material, drill cuttings or crushed gravel, which is used to confine energy at the top of the explosive charge in the borehole (ISEE, 2011).
- *Bench Height* the vertical distance from the top of a bench to the floor (ISEE, 2011).
- *Subdrill* Length of borehole that is drilled below grade level of the floor of the bench, to ensure rock breakage to the grade surface (ISEE, 2011).
- Weight per delay Simply the weight of explosives that will be detonated at the same time. In Figure 2, for example, if each borehole is loaded with 4 kg of explosives, the maximum weight of explosives per delay would be 12 kg / delay.

Poor blast design can result in unsafe levels of vibration and noise, and increase the risk of flyrock.

#### 2.1.2 Flyrock

Flyrock is simply rock that is launched outside of the blast area due to the force of an explosion (Kecojevic and Radomsky, 2005). There is certainly no lack of theoretical and experimental predictions of flyrock projectiles. Langefors and Kihlstrom (1963), Ladegaard-Pederson and Persson (1973), Lundborg (1974,1981), Holmeberg and Persson (1976), and Roth (1979) conducted experiments, including high speed camera documentation of blasts, and have created

quick references for expected flyrock distances with inputs of hole size, explosive charge / weight etc. It is concluded, and generally known that flyrock is caused by a miscalculation between the required explosive energy and the strength of the surrounding rock mass. Kecojevic and Radomsky (2005) propose the following reasons for such miscalculations:

- a) Unforeseen discontinuities in the geological structure in which one is blasting
- b) Poor blasthole layout / design or loading
- c) Insufficient burden
- d) Excessive explosive energy concentration
- e) Inadequate stemming

Flyrock poses a risk to damaging neighbouring houses, site equipment, and injury or fatalities of workers or of the public within close proximity of the blast (Rajaram et al., 2005). Figure 3 shows the distribution of causes of blasting accidents, including both fatalities and injuries, on American coal mining blasts between 1978 and 2001 (Kecojevic and Radomsky, 2005). Although separation of data is not provided by Kecojevic and Radomsky (2005), it is suggested by Rajaram *et al.*, (2005) that flyrock is the leading cause of fatalities in the surface blasting operations in the United States.



Figure 3: Causes of blast accidents in coal surface mining in the United States (1978-2001) (modified from Kecojevic and Radomsky, 2005)

#### 2.1.2.1 Mitigation techniques

In order to contain the blast and ensure the risks of flyrock are minimized, appropriate measures can be made to mitigate the factors described from (a) to (e), including detonation initiation at the bottom of the hole, appropriate stemming depths, and adequate burden. The blast should be designed to minimize the risk of flyrock, and as a contingency, the blaster may also employ blasting mats. Blasting mats are typically composed of treads of recycled tires woven with steel cables and can weigh up to two and a half tonnes (Holmberg, 2000). They are carefully laid, overlapping consecutive mats, over the surface of the blast prior to detonation and can provide adequate protection against flyrock, particularly in urban settings, without affecting fragmentation. However, carefully laying these mats without disrupting the tie-in sequencing between blast holes is a very time consuming task and may not be possible on very large blast patterns.

#### 2.1.3 Vibration

Ground vibrations are an unavoidable adverse environmental effect of urban blasting. Neighbouring structures, including residential homes can be cracked during blasting due to (Dowding, 1985):

- a) Permanent ground deformation due to heave or gas pressures
- b) Vibratory settlement of structure foundation
- c) Direct vibratory cracking due to ground vibrations

Ground vibrations become a major safety concern for poorly designed, close-proximity blasts where vibrations may significantly exceed thresholds of surrounding material strength such as foundations, drywall, equipment, etc., as well as the fatigue of new construction such as curing concrete. There is extensive literature devoted to the investigation of various structures' responses to blast induced ground vibrations and many regulatory requirements have reflected these studies in a very conservative manner. However, many regulations only stipulate a maximum Peak Particle Velocity (PPV), when in actuality Dowding (1985) has shown that the frequency of such waves plays a very important role in structural response. Figure 4 shows the allowable limits for residential homes including both the PPV and frequency.



Figure 4: Safe levels of blasting vibration for residential houses (modified from Siskind *et al.*, 1980)

#### 2.1.3.1 Mitigation techniques

In order to ensure the safety of surrounding structures, if required, blast monitoring devices such as a seismometer can be placed at the closest point of the closest structure to the blast. A seismometer includes an amplifier, microphone, geophones, power supply and a recorder to measure PPV (mm/s), frequency (Hz) and air waves (dBL) in real time on a seismograph. Self triggering systems allow low cost blast monitoring and the output data can help the blast designer adjust layout, or explosive loading if necessary (Dowding, 1985). The blaster can use the seismograph to ensure compliance under vibration limits and adjust the blast design (i.e. reducing the weight of explosives per delay) as required.

#### 2.1.4 Air blast

Air blast is the term used to describe the pressure waves exerted from an explosion (Dowding, 1985). The amplitude of the air pressure is the parameter of importance. The higher frequency waves produce the familiar sound which accompanies blast excavation of rock, however it is the

lower-frequency non-audible portion which excites structures and may cause a secondary and audible rattle within a structure.

There are two risks which air blasts pose including direct human irritation, and pressure causing damage on neighbouring structures such as breaking windows. Figure 5 shows the various decibel levels, which have been converted to pressures (Atlas Powder Co., 1987). This informative table provides regulatory standards, including human threshold for pain as regulated under the US Occupational Safety and Health Administration department as well as structural thresholds.



Figure 5: Overpressure conversion table for air blasts db to KPa (modified from Atlas Powder Co., 1987).

#### 2.1.4.1 Mitigation techniques

The sound waves and respective frequencies can be measured with the seismometer, allowing the blaster to make necessary changes to the blast design, layout, or explosives used in a blast. There are several ways to reduce air blast intensities including but not limited to (Atlas Powder Co., 1987):

- a) using a stemming height greater than or equal to the burden length
- b) reducing the weight of explosives per time delay between holes

- c) avoid blasting on days when wind/atmospheric conditions create air blast focusing
- d) using bottom hole initiation
- e) avoiding short delays.

# 2.2 Blasting in the News

The research presented in this thesis was prompted by the overwhelming negative attention that the blasting industry is receiving in the news. The following are some snippets of blasting in the media, describing how blasting is portrayed as a danger/nuisance to the general public:

- 2010 Kelowna (Castanet) "currently Kelowna has no jurisdiction under the area of blasting . . even though the city often hears from residents who are upset about blasting" (Nieoczym, 2010).
- 2010 West Kelowna (Castanet) "Mike McVicar [Smith Creek resident] doesn't like the idea of explosives going off directly in front of his home" (Moore, 2010).
- 2010 Nanaimo (Nanaimo Bulletin) "When it goes, everything in the house rattles, and I'm [Nanaimo resident Ingrid Herchak] concerned repeated blasting is making the rock shelf above the backyard unstable" (Gorman, 2010).
- 2011 Shawnigan Lake (Vancouver Sun) "An explosion at a Shawnigan Lake gravel pit Tuesday hurled baseball-sized, jagged rocks 400 meters, hitting three people. One woman lost her arm" (Derosa, 2011).

# 2.3 Difficulties Regulating the Issues

The unique nuisances of the blasting industry extend off of the construction site. WorkSafeBC limits the scope of their involvement to the safety of the workers on the construction site. Vibration and overpressure are outside of their mandate. The complaints and issues made by concerned citizens are therefore left to the municipality.

## 2.3.1 Difficulties regulating at the municipal level

It is a difficult process to adopt a bylaw that attempts to regulate blasting operations in a municipality. A city generally has a lack of understanding of which regulating bodies has control over the issue, a complete absence of blasting expertise within municipal staff, including the

engineering department, as well as a lack of funding, and fear of the assumption of risk. The issues raised are evaluated in British Columbia and Ontario.

## 2.3.1.1 Lack of understanding

Damage claims, or complaints of blasting operations made by the community put the municipalities in a difficult position. Kelowna, BC has recently identified and started to investigate solutions to the issue of residents' complaints. In this particular municipality, residents are concerned that blasting may damage their property. In a bulletin released by city hall, the City of Kelowna writes:

"With several different ministries responsible for regulating various aspects of blasting, residents and politicians alike often don't know who to turn to if they have concerns" (City of Kelowna, 2010).

Sudbury poses the same difficulties. In a class action suit between disgruntled neighbours and a blasting contractor, which will be described later, there is an obvious absence of control over urban blasting issues within the city. City officials are taking complaint calls and directing them to Ministry of the Environment, who they assume have jurisdiction over the issue, who then revert the complaints back to their municipal authorities (Whitehouse, 2010b).

## 2.3.1.2 Lack of expertise and funding

Municipal governments do not have blasting experts readily available without expensive consulting costs. When a complaint is made to the city, the call is redirected to other government organizations because they simply do not have the knowledge to respond to the frustrated community. Further, this also results in municipalities attempting to hand the issue back to the larger budgeted provincial governments. Meeting minutes from an internal City of Sudbury discussion states:

". . . from a legal liability perspective, taking on the regulation of blasting for commercial/residential activity in the City may be more than the corporation is prepared to take on at this time. The city has neither the staff nor expertise (e.g. rock engineers) on hand to deal with this. It was felt that the Ministry of the Environment is in a better financial position to expand its role to include this activity" (Gerretsen, 2008).

In British Columbia, it is clear that Kelowna is not the only community struggling with the issue and city councillor Luke Stack suggests a more efficient solution:

"a more productive course of action would be for cities to band together and lobby the provincial government for changes. "Rather than us tackling it one city at a time this should be something that's brought back to the provincial government which does have legislative authority [to regulate blasting]' " (City of Kelowna, 2010).

Further, if bylaws were put in place by a municipality it can become very costly from an administrative standpoint to enforce the issue including: establishing a complaint centre, investigating violations of the bylaw, monitoring compliance etc. Gorman writes:

"Blasting bylaws have been established in municipalities like West Vancouver, Surrey, Burnaby and Victoria. Consultation with them has pushed Nanaimo city hall to move in the direction of providing guidelines and education, but to fall short of enacting any bylaws for now" Gorman (2010).

The cities of Ottawa and Windsor had a series of guidelines in place under a municipal wide blasting bylaw; however both municipalities have since repealed them from their legislation due to inability to actually regulate the issue (Whitehouse, 2010b).

## 2.3.1.3 Assumption of risk / liability

It is a unanimous concern between all municipalities currently debating the implementation of blasting regulations that the assumption of risk and liability is too great to adopt scientific limits on parameters they are unfamiliar with. Gorman writes:

"Currently, blasting is not regulated by most municipalities nor the province, but Nanaimo city council is taking a look to see if it should step in to oversee the practice. It's approaching the issue cautiously. 'The municipality takes on the risk if a bylaw is passed,' said Toby Seward, the city's director of development" Gorman (2010).

## 2.3.2 Summary

An overview and analysis of Canadian blasting regulations, and an understanding of flyrock incidents and complaints of vibration and overpressure, will aid with the identification of the most suitable governing body to regulate each issue.

# **3** Blasting Regulations

In Canada, blasting laws and regulations were evaluated in the federal, provincial, municipal, and private insurance sectors. Provincial regulations in Canada were also compared with state regulations in the United States of America and Australia. The intention of this investigation was to view the disparity between the specific wording and prescriptive nature of occupational health and safety regulations that pertain to flyrock, vibration and overpressure.

## 3.1 Federal Government of Canada

The federal government has a strict set of guidelines and regulations that are directly related to the safety and security of manufacturing explosives, their storage, import and transportation into and within the country (Natural Resources of Canada, 2010). The Canadian Department of Natural Resources (NRCan) regulates these activities by controlling the issuance of permits. These authorities comprise the federal Explosive Regulatory Division (ERD).

All explosives, initiation systems, and magazines (large storage containers for explosive material and accessories), are registered with the government of Canada, and can be inspected at any time without notice by a government official. The federal government also strictly regulates the manufacture and import of explosives material and accessories. A factory license must be issued prior to any manufacturing, and a complete environmental assessment of the company's operations is a condition of the certificate. In addition, after "amendment No. 6 to the Transportation of Dangerous Goods Regulations," the same division of NRCan also issues permits for the transportation of explosives rather than Transport Canada. Transport Canada, on the other hand, sets the guidelines on those explosives that can be transported together or must be transported separately. There are six classes of explosives that are separated into compatibility groups defining classes of explosives that can be transported with other classes (Transport Canada, 2009).

The federal regulations are specific to the explosive material and accessories rather than any blasting practice. Security and safety are the primary concerns, which provide the foundation for these laws. For example, with regard to magazine storage, there "must be a  $1.2 \text{ m}^2$  floor area in a

magazine for each tonne of industrial explosive," to allow adequate ventilation and reduce the concentration of explosives (Natural Resources of Canada, 2010).

Issues surrounding flyrock, or vibration and overpressure exceeding allowable levels are not regulated by the federal government of Canada.

## 3.2 **Provincial Regulations**

Every provincial government in Canada has established an Occupational Health and Safety (OHS) Act (AWCBC, 2010). The regulations in each province were analyzed with respect to flyrock, overpressure and vibration.

### 3.2.1 British Columbia – WorkSafeBC

In British Columbia, blasting operations are covered by Section 21 of the Occupational Health and Safety Act, which is regulated by WorkSafeBC (WorkSafeBC, 2010). This document outlines best practices for blasting to ensure the safety of employees on the construction site, and include guidelines on:

- a) General Requirements: blaster's responsibility, training, blasting logs and reporting incidents.
- b) Certification: ensuring the blaster is adequately certified and trained to perform the operations.
- c) Storage and Transportation: additional information to complement federal regulations on the storage and transportation of explosives including on-site guidelines.
- d) Handling Explosives, Drilling and Loading: specifications regarding the preparation of the blast layout for a blast.
- e) Initiation and Firing: procedures for initiating safety fuses, electrical and non-electrical detonators, and firing guidelines.
- f) Misfires and Returning to the Blast Site: these procedures ensure that a qualified blaster is the only employee inspecting the detonation of all explosives, and implementing careful inspection of the blast site prior to the return of other workers to the site.
- g) Specialized Blasting Operations: specifications for fireworks, pyrotechnics, avalanche control etc.

There are no guidelines that govern the off-site noise or vibration limits caused by blasting operations, regulated by WorkSafeBC.

A construction incident or accident involving flyrock, whether discharged off-site or not, is a violation of Section 21.66 (1) of the provincial OHS Act, which states:

"The blaster must take precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material" (Work Safe BC, 2010).

As stated in the Workers Compensation Act, in the case that the Act is violated, the offender is given a fine not exceeding \$600 000 or up to 6 months in prison, or a combination of the two (WorkSafeBC, 1996).

## 3.2.2 British Columbia – Ministry of Mines

The BC Ministry of Mines regulates blasting operations on a site-by-site basis (BC Ministry of Mines, 1996). However, these regulations are limited to sites defined as a mine, which is stated in the BC Mines Act as:

"(a) a place where mechanical disturbance of the ground or any excavation is made to explore for or to produce coal, mineral bearing substances, placer minerals, rock, limestone, earth, clay, sand or gravel, (b) all cleared areas, machinery and equipment for use in servicing a mine or for use in connection with a mine and buildings other than bunkhouses, cook houses and related residential facilities, (c) all activities including exploratory drilling, excavation, processing, concentrating, waste disposal and site reclamation, (d) closed and abandoned mines, and (e) a place designated by the chief inspector as a mine" (BC Ministry of Mines, 1996).

As part of the permitting process, the mining manager is responsible for ensuring that vibration and overpressure are within acceptable limits, and the assigned mines inspector strictly enforces these limits with warnings and stop-work orders.

It is apparent that the BC Ministry of Mines has measures to mitigate the adverse environmental effects of blasting operations on the neighbours of mines and quarries. Apart from municipal bylaws, this is the only regulating body with jurisdiction in BC that regulates urban blasting – when a site defined as a mine or quarry is in close proximity to urban areas. Thus there is a noticeable lack of regulations governing urban blasting in BC.

#### 3.2.3 Alberta

In Alberta, blasting operations are regulated by Part 33 of the Occupational Health and Safety Code (Government of Alberta, 2009). The document outlines best practices for blasting that are similar to those provided by WorkSafeBC. Safety guidelines are outlined for handling explosives, drilling, loading, firing, destroying explosives and specific blasting activities (avalanche blasting, seismic blasting etc.). There are no guidelines that govern the off-site noise, or vibration limits caused by blasting operations, regulated by the province of Alberta. Flyrock is categorized under section '498 Community Protection' and '499 Safe Distance' of the 'Firing Procedures' which states:

"498 If an employer or a blaster is conducting blasting operations in the vicinity of a city, town, village, hamlet, inhabited campsite, other inhabited area, building, railway or road, the employer and the blaster must take adequate precautions against possible injury to persons and damage to property by: (a) limiting the explosive charge to the minimum required to do the job, (b) using a blasting mat or other suitable protective device over the drill hole, bore hole or blasting area, (c) closing roads, trails, paths and other approaches to the blasting area during blasting operations, and (d) placing warning signs or barricades or using flag persons to ensure that no unauthorized person enters or remains in the area that is potentially dangerous.

499 When the blasting is being done, a blaster must ensure that: (a) all workers at the work site are protected from falling rocks, flying debris, mud and anything else that is disturbed, agitated or displaced by the blast, and (b) no worker fires a charge until all workers are protected by suitable cover or are at a safe distance from the blast" (Government of Alberta, 2009).

In the case that section 498 or section 499 of the OHS Code are violated as a first offence, the offender is given a fine not exceeding \$500,000 or up to 6 months in prison, or a combination of the two (Government of Alberta, 2000).

#### 3.2.4 Saskatchewan

In Saskatchewan, blasting operations are regulated under both the OHS Regulations, as well as the Mines Regulations. Part 26 of the OHS Regulations include brief guidelines on blaster qualifications, storage and transport considerations, and require written safety procedures (Government of Saskatchewan, 1996). The application for these regulations is for the use of explosives in all cases except mines and seismic blasting. Although Division 4 of the Mining Regulations provides extensive guidelines (similar to those provided by WorkSafeBC) for the use of explosives in underground and surface mines (Government of Saskatchewan, 2003), they are limited only to the use at mine sites, and are not regulated for construction or urban blasting. That being said, there are no urban blasting regulations for any of the adverse environmental effects of blasting, provided by the Province of Saskatchewan.

## 3.2.5 Manitoba

In Manitoba, blasting operations are regulated under both the OHS Regulations, as well as the Operation of Mines Regulations. Similar to Saskatchewan, the Operations of Mines Regulations are solely applicable to mine sites (Government of Manitoba, 1994). However, the OHS Regulations do provide procedures for the protection of the surrounding community and site workers from potential flyrock (Government of Manitoba, 2006). Section 34.16 (2) and 34.16 (3) (b) of the regulations stipulate:

"34.16(2) Before blasting occurs, an employer must ensure that adequate precautions are taken against possible injury to persons and damage to property, including without limitation, ensuring that (a) the blaster or supervising blaster limits the charge used to the minimum required to do the blast; (b) a blasting mat or other suitable means of protection is used to control flying debris; (c) unauthorized persons are warned not to enter or remain in the area of the blast site (d) roads, trails, paths and other approaches to the blast site are closed during blasting operations; (e) the person who controls any railway within the blast site is given advance notice of the blasting operations to be carried out; and (f) sufficient warning is given before a blast takes place.

34.16(3) An employer must ensure that the blaster does not fire a charge until all workers and other persons are at a safe distance from the blast site, or if a worker or other person is required to remain in the blast site, he or she is protected by suitable cover from falling rocks, flying debris, mud or anything else that is disturbed, agitated or displaced by the blast" (Government of Manitoba, 2006).

In the case that either of these sections of the OHS Code are violated as a first offence, the offender is given a fine not exceeding \$250,000 or up to 6 months in prison, or a combination of the two (Government of Manitoba, 2010).

Vibration and overpressure, as a result of blasting operations, is not regulated by the Province of Manitoba.

#### 3.2.6 Ontario

In Ontario, provisions protecting the safety of blasters and other personnel on the blasting site are outlined in Part VI of Regulation 854 – Mines and Mining Plants, as well as Regulation 213 – Construction Projects under the Ontario OHS Act (Ontario Ministry of Labour, 1990). The construction blasting regulations are similar in nature to those in British Columbia. Subsections include specifications regarding: blaster qualifications, on site procedures, the use of blasting mats, equipment and site security. The regulations are very similar to those regulated by Work Safe BC, however for construction blasting in Ontario, blasting mats are required to prevent the discharge of flyrock off-site. Section 201 of Regulation 213 of the Ontario OHS Act states:

"Blasting mats shall be used to prevent flying objects caused by blasting operations from endangering persons and property located on or adjacent to a project. O. Reg. 213/91, s. 201" (Ontario Ministry of Labour, 1990).

Blasting mats may cause declines in productivity, however they have been proven to be very effective in the reduction of flyrock risk (Holmberg, 2000). However, procedures to lay the blasting mats are not provided, and if this practice is not properly performed, the blast may not be fully contained. In these instances, there is no violation under the OHS Act, as it only stipulates the use of blasting mats.

However, in the province of Ontario, flyrock is considered a contaminant. A contaminant by definition under the Ontario Environmental Protection Act (EPA) is a solid, liquid, gas, odour, heat, sound, vibration or radiation which results directly or indirectly from human activity and may cause an adverse affect (Ontario Ministry of the Environment, 1990). In any instance that flyrock is discharged from blasting operations, whether mining or construction related, the blasting company may be fined under Section 14 (1) of the Environmental Protection Act which states:

"Subject to subsection (2) [Unless otherwise authorized] but despite any other provision of this Act or the regulations, a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect" (Ontario Ministry of the Environment, 1990).

Violation of this regulation results in a fine of no less than \$25,000 on first offence (Ontario Ministry of the Environment, 1990).

Noise and vibration pollution are also regulated by the Ontario Ministry of the Environment (MOE). There are cautionary limits which are recommended in publication NPC-119 (sound level limits for noise and vibration produced by blasting) for mines and quarries only (Ministry of the Environment, 2010). In Ontario, there are no quantitative regulations for vibration or overpressure for urban (or "construction") blasting.

It is important to note that there is an Ontario Provincial Specification Standard (OPSS) document which was developed for the province of Ontario (OPSS-120) which outlines blasting procedures, including the use of a professional engineer, seismometers, pre-blast surveys and places restrictions on allowable PPV for different frequencies (Ministry of Transportation Ontario, 2008). This OPSS document can regulate blasting risks including all of flyrock, vibration and overpressure by inclusion in the contract documents, and includes all of the advantages of professional monitoring at an agreed upon cost prior to construction. However, these specifications are predominantly used on Ministry of Transportation Ontario (MTO) projects, as they are directed towards high-production, rural areas (R. Cyr of Explotech Consulting, pers. comm., Nov. 22, 2010). They are rarely, if at all, adopted by urban contracts because it specifies pre-blast surveys to be conducted for all structures, utilities, and buildings within 150 m (which is typically only 65 m for urban blasting) of the blast site. In dense, populated areas, this can put the pre-blast survey costs up into the \$75,000 range.

#### 3.2.7 Quebec

In the province of Quebec, explosives and blasting procedures are regulated under the Safety Code for the construction industry as well as other regulations which are applicable to mining operations only. The blasting procedures outlined in the construction Safety Code are similar to those provided by WorkSafeBC (Government of Quebec, 1981). In order to reduce the risk of flyrock, it is also stated in Section 4.7.5:

"When blasting is done in the vicinity of a building, railway line, road or electric distribution line, the load must be limited and a blasting mat used. The backfill must not contain single particles or conglomerates larger than 5 millimetres. The blasting mat must be deposited but not slid into place" (Government of Quebec, 1981).

When this section of the Safety Code is violated (and thus the OHS Act is violated), the offender is fined between \$1500 and \$3000 for a first offence (Government of Quebec, 1979).

There are no regulations that govern the off-site noise, or vibration limits caused by blasting operations, regulated by the province of Quebec.

## 3.2.8 Nova Scotia

Nova Scotia's guidelines and regulations for blasting safety are included under Section 82 of the Occupational Health and Safety Act (Government of Nova Scotia, 2008). Major categories include: general duties and responsibilities, authority to conduct and supervise blasting activity, specialized blasting and blasting by uncertified persons, handling and storing explosives, drilling, loading, firing, after firing and misfires. More comprehensive regulations tailored directly to urban blasting are also regulated at the municipal level, and will be discussed later. As specified in Sections 82.63, 82.64 and 82.65:

"Placement of charge and other blast features:

63 An employer must ensure that a charge is not fired until a blaster has ensured that the placement of the charge and all other features of the blast are sufficient to minimize risk of injury to persons and damage to property.

Airblast, ground vibrations and fumes:

64 An employer and a blaster must ensure that sufficient precautions are taken to prevent injury to persons or damage to property from any of the following: (a) airblast resulting from a blast; (b) ground vibrations resulting from a blast; (c) fumes resulting from a blast.

Flying material:

65 (1) An employer and a blaster must ensure that sufficient precautions are taken to prevent injury to persons or damage to property from flying material resulting from a blast. (2) Precautions to prevent injury or damage from flying material may include any of the following: (a) using blasting mats of appropriate size and strength to minimize the amount of flying material;(b) using a sufficient amount of burden to minimize the amount of flying material;(c) removing persons and property from an area where flying material may create a hazard;(d) providing shelter sufficient to protect persons and property from flying material" (Government of Nova Scotia, 2008).

In the case that either of these sections of the OHS Code are violated as a first offence, the offender is given a fine not exceeding \$250,000 or up to 2 years in prison, or a combination of the two (Government of Nova Scotia, 1996).

#### 3.2.9 New Brunswick

In New Brunswick, blasting operations are regulated under the Occupational Health and Safety regulations Section 12 (Government of New Brunswick, 2001). These safety regulations are similar to those in British Columbia with major categories including: control of blasting operation, general safety, handling, before firing, after firing, misfires, records, warning signs, housekeeping, and codes of practice. Section 178 'Blasting mats and loose rocks,' states:

"178 An employer shall ensure that (a) blasting mats are used where there may be a hazard to persons or property from flying debris, (b) loose rocks are scaled off the sides of excavations and removed from the crest after blasting and before any work is resumed" (Government of New Brunswick, 2001).

In the case that either of these sections of the OHS Code are violated as a first offence, the offender is given a fine not exceeding \$250,000 or up to 6 months in prison, or a combination of the two (Government of New Brunswick, 1983).

Vibration and overpressure, as a result of blasting, is not regulated by the Province of New Brunswick.

#### 3.2.10 Newfoundland

Newfoundland blasting operations are regulated under Part 19 of the Occupational Health and Safety Regulations (Government of Newfoundland, 2009). The regulations are very similar to those provided by WorkSafeBC with major categories including: blaster qualifications, records, storage, prohibitions, transportation, drilling, handling, preparing the blast, safety fuse, loaded holes, restriction, electrical initiation, pre-firing, protection, firing, post-firing, unique blasting operations, seismic blasting and misfires. Similar to the regulations enforced by the province of Nova Scotia, brief safety requirements are provided for flyrock, vibration and overpressure. Under Section 437 of "Protection" it is stated:

"437 (1) An employer shall take precautions to ensure that persons and property at or near the workplace are protected and that hazards of flying material, airblast, ground vibration or fumes from the blast are minimized. (2) Where there is a danger to the safety of persons or property, a blasting mat of adequate size and strength or adequate cover shall be used" (Government of Newfoundland, 2009). If section 437 of the OHS Code is violated as a first offence, the offender is given a fine between \$500 and \$250,000 or up to 1 year in prison, or a combination of the two (Government of Newfoundland, 1999).

#### 3.2.11 Prince Edward Island

In Prince Edward Island (PEI), blasting operations are regulated under Part 26 of the Occupational Health and Safety Regulations (Government of PEI, 1987). In these regulations, there are no requirements for the blaster to take specific measures to protect against flyrock, vibration or overpressure.

#### 3.2.12 Yukon Territory

Yukon Territory regulates blasting operations under Section 14 of the Occupational Health and Safety Act (Government of Yukon Territory, 2006). The document has extensive guidelines for the protection of site workers which are similar to those outlined by WorkSafeBC. However, there are no specific regulations for the protection of the public against flyrock, vibration, or overpressure. This gap in legislation was the main defence of a blasting company who caused a severe flyrock incident that did not place any construction workers in danger, but did affect people in nearby trailers (Government of Canada, 2010). This particular incident will be discussed later in more detail.

#### 3.2.13 Northwest Territory & Nunavut

The Northwest Territories regulate blasting operations under the Explosives Use Act (Government of Northwest Territories, 1990). The document has extensive guidelines for the protection of site workers which are similar to those outlined by WorkSafeBC. However, there are no specific regulations for the protection of the public (or site workers) against flyrock, vibration, or overpressure.

#### **3.2.14** Summary of provincial regulations

A comparison of the urban blasting related regulations in Canada, concerning flyrock, vibration and overpressure is shown for all provinces in Canada in Table 1.

Province	Regulating Document	Regulation of Concern	Part	Regulation	Penalty
British		Flyrock	21.661(1)	The blaster must take precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material	Up to \$618,730
Columbia	ONSAC	Vibration	N/A	N/A	N/A
Province British Columbia Alberta Saskatchewan Manitoba		Overpressure	N/A	N/A	N/A
Alberta	OHS Act	Flyrock	33.498- 499	<b>498</b> If an employer or a blaster is conducting blasting operations in the vicinity of a city, town, village, hamlet, inhabited campsite, other inhabited area, building, railway or road, the employer and the blaster must take adequate precautions against possible injury to persons and damage to property by: (a) limiting the explosive charge to the minimum required to do the job, (b) using a blasting mat or other suitable protective device over the drill hole, bore hole or blasting area,(c) closing roads, trails, paths and other approaches to the blasting area during blasting operations, and (d) placing warning signs or barricades or using flag persons to ensure that no unauthorized person enters or remains in the area that is potentially dangerous <b>499</b> When the blasting is being done, a blaster must ensure that (a) all workers at the work site are protected from falling rocks, flying debris, mud and anything else that is disturbed, agitated or displaced by the blast, and (b) no worker fires a charge until all workers are protected by suitable cover or are at a safe distance from the blast.	Up to \$500,000
		Vibration	N/A	N/A	N/A
		Overpressure	N/A	N/A	N/A
		Flyrock	N/A	N/A	N/A
Saskatchewan	OHS Act	Vibration	N/A	N/A	N/A
Alberta Saskatchewan		Overpressure	N/A	N/A	N/A
Manitoba	OHS Act	Flyrock	34.16	Before blasting occurs, an employer must ensure that adequate precautions are taken against possible injury to persons and damage to property, including without limitation, ensuring that (a) the blaster or supervising blaster limits the charge used to the minimum required to do the blast; (b) a blasting mat or other suitable means of protection is used to control flying debris; (c) unauthorized persons are warned not to enter or remain in the area of the blast site (d) roads, trails, paths and other approaches to the blast site are closed during blasting operations; (e) the person who controls any railway within the blast site is given advance notice of the blasting operations to be carried out; and (f) sufficient warning is given before a blast takes place. When the blasting is being done, a blaster must ensure that (a) all workers at the work site are protected from falling rocks, flying debris, mud and anything else that is disturbed, agitated or displaced by the blast, and (b) no worker fires a charge until all workers are protected by suitable cover or are at a safe distance from the blast.	Up to \$250,000
		Vibration	N/A	N/A	N/A
		Overpressure	N/A	N/A	N/A

Province	Regulating Document	Regulation of Concern	Part	Regulation	Penalty	
Ontario	OHS Act (201- 213) / Environmental Protection Act	Flyrock	201- 213.2-4	<b>201-213</b> Blasting mats shall be used to prevent flying objects caused by blasting operations from endangering persons and property located on or adjacent to a project. <b>2-14</b> Subject to subsection (2) [Unless otherwise authorized] but despite any other provision of this Act or the regulations, a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect.	Immediate \$25,000	
	(2-14)	Vibration	N/A	N/A	N/A	
	. ,	Overpressure	N/A	N/A	N/A	
Quebec	Construction	Flyrock	4.7.5	When blasting is done in the vicinity of a building, railway line, road or electric distribution line, the load must be limited and a blasting mat used. The backfill must not contain single particles or conglomerates larger than 5 millimetres. The blasting mat must be deposited but not slid into place	Between \$1500 and \$3000	
	Salety Code	Vibration	N/A	N/A	N/A	
		Overpressure	N/A	N/A	N/A	
Nova Scotia	Occupational Health and Safety Act	Flyrock	82.63-65	<b>63</b> An employer must ensure that a charge is not fired until a blaster has ensured that the placement of the charge and all other features of the blast are sufficient to minimize risk of injury to persons and damage to property. <b>65</b> (1) An employer and a blaster must ensure that sufficient precautions are taken to prevent injury to persons or damage to property from flying material resulting from a blast. (2) Precautions to prevent injury or damage from flying material may include any of the following: (a) using blasting mats of appropriate size and strength to minimize the amount of flying material; (b) using a sufficient amount of burden to minimize the amount of flying material; (c) removing persons and property from an area where flying material may create a hazard; (d) providing shelter sufficient to protect persons and property from flying material."	Up to \$250,000	
			Vibration	82.64	64 An employer and a blaster must ensure that sufficient precautions are taken to prevent	
			Overpressure	82.64	blast; (b) ground vibrations resulting from a blast; (c) fumes resulting from a blast.	
New Brunswick	Occupational	Flyrock	12.178	An employer shall ensure that (a) blasting mats are used where there may be a hazard to persons or property from flying debris, (b) loose rocks are scaled off the sides of excavations and removed from the crest after blasting and before any work is resumed	Up to \$250,000	
New Branswick	Safety Act	Vibration	N/A	N/A	N/A	
	Surcey Act	Overpressure	N/A	N/A	N/A	
Dringo Edward	Occupational	Flyrock	N/A	N/A	N/A	
	Health and	Vibration	N/A	N/A	N/A	
Islanu	Safety Act	Overpressure	N/A	N/A	N/A	
	Occupational	Flyrock		(1) An employer shall take precautions to ensure that persons and property at or near the	Between	
Newfoundland	Health and Safety Act	Vibration	19.437	from the blast are minimized. (2) Where there is a danger to the safety of persons or property,	\$500 and	
		Overpressure		a blasting mat of adequate size and strength or adequate cover shall be used.	\$250,000	
## 3.3 Municipal Regulations by Province

Municipal bylaws were analysed for regulations on blasting operations. In British Columbia, every municipality was investigated by conducting a review of municipal websites. Using references from several newspaper articles and suggestions from a professional engineer with blast monitoring expertise nationwide, individual municipalities in Ontario and Nova Scotia were also investigated.

#### 3.3.1 British Columbia

In British Columbia, there are 157 municipalities which service 85% of the provincial population (UBCM, 2006). Using the methodology described in Figure 6, all 157 municipalities were investigated for blasting-operation regulations. It was found that there are 20 municipalities with a "blasting bylaw," three of which specifically limit blasting operations to particular times under the "Noise Bylaw," and one municipality that regulates blasting under the "good neighbour bylaw."



Figure 6: Methodology for the investigation of British Columbia municipal bylaws

Every "blasting" and "good neighbour" bylaw has an administrative regulation which requires a blasting permit to work within their municipality. The regulations were compared among other common subcategories of safety-oriented regulations. These are listed below with an example:

- *Permit* "No person shall blast or carry on blasting operations without first obtaining a blasting permit from the (municipal) Engineer" (City of Prince Rupert, 2004).
- Monitor "At least one recording seismograph shall be used on every blast and the records retained. The Blaster shall prepare seismograph readings at the nearest structure to the blast and the seismograph records should be kept and available to citizens and the City upon request" (City of Colwood, 1994).
- Blasting Mats "No person shall engage in blasting without taking all precautions necessary for the protection of persons or property to minimize the hazard of flying material resulting from a blast, by the use of blasting mats, or clean fill sand free of rock" (District of Metchosin, 1994).
- *Notification of Blasting* "No person may blast, carry on blasting, or use an explosive agent without giving notice at least 24 hours before the blasting commences to:
  - (a) owners and occupants of any building within a radius of 100 m of the blasting site;
  - (b) the School District, Principal or person in charge of a school within a radius of 300 m of the blasting site; and
  - (c) the District of Invermere in writing, including the site location and site contact information" (District of Invermere, 2007).
- Pre-blast surveys "When an owner proposes to blast, the owner shall first apply to the director for a permit by providing the following: a report on the results of a pre-blast survey which shall be made of all principal structures and outbuildings, swimming pools, retaining walls, patios and driveways on any parcel of land within such distance of the blasting as the Engineer may specify. The Blaster shall cause the survey to be conducted after notice in writing to the Affected Owners (being the owners of the properties to be surveyed) and after giving the Affected Owners a reasonable opportunity to be present or to have an agent present" (District of West Vancouver, 1996).
- *Time Restrictions* "A holder of a blasting permit must only carry out blasting Monday to Friday between the hours of 8:00 a.m. and 4:00 p.m." (City of Abbotsford, 2010).
- Insurance Limit (no less than) "No permit for blasting shall be issued by the City Engineer until the applicant has given to the City Engineer, a security for damage to persons who, or whose property, may be injured by the blasting. This security shall be in

the form a public liability and property damage insurance satisfactory to the City, with minimum coverage of \$5,000,000 inclusive, for loss or damage in respect of injury or death of any person or persons or damaged property or both from any one accident or occurrence" (City of Port Coquitlam, 1995).

- Blasting Consultant (if necessary) "Where a proposed blasting site is located within 150 m of an existing structure or is subject to, or is likely to be subject to rock falls, erosion, land slip, subsidence, avalanche or other similar risk, the Building Inspector may, in his sole discretion, require an applicant for a blasting permit to provide a report from a Professional Engineer, licensed to practice in the Province of British Columbia and experienced in geotechnical engineering and blasting, certifying that the blasting plan is acceptable for the site described in the permit application" (City of Abbotsford, 2010).
- *Fine (not more than)* "Every person who, without lawful excuse, contravenes this bylaw by willfully doing any Act which it forbids, or omitting to do any act which it requires to be done, is guilty of an offence and is liable, on summary conviction to a fine of not less than \$1000 and not more than \$5000 for a first offence and for each subsequent offence to a fine of not less than \$2500 and not more than \$7500" (City of Rossland, 2009).

Using the above subcategories, the municipalities with blasting regulations in British Columbia are summarized in Table 2, and are provided in much more detail in Appendix A. It was found that the municipalities with blasting oriented bylaws range in population from 2000 to 400,000. Aside from the three municipalities (highlighted in yellow in Table 2) which are regulated under the "noise bylaw," the bylaws are founded on a permit application process. Six of the 23 municipalities with bylaws require monitoring of every blast with a seismometer. Eleven require the use of "blasting mats," "clean sand fill," or "some other device" used to protect the public from flyrock. A majority of the municipalities require the blaster (or someone acting on behalf of the blaster) to notify the public within a certain radius of the upcoming blasting work. However, many of these municipalities have undefined times (i.e. "prior to the blast") and radius (i.e. "within a reasonable distance"). Five municipalities require, or reserve the right to require, preblast surveys to be conducted prior to blasting, and the use of an engineer at the blaster's or owner's expense.

Municipality	Bylaw No.	Permit	Monitor	Flyrock Protection	Notification of Blasting	Pre-Blast Surveys	Time Restrictions	Insurance Limit (not less than)	Blasting Consultant (Mandatory)	Blasting Consultant (Upon Request)	Fine (not more than)
Abbotsford	1941-2010	$\checkmark$	Х	√	✓	Х	✓	\$5,000,000	Х	✓	\$10,000
Burnaby	138	✓	Х	Х	✓	Х	✓	Х	Х	Х	\$100
Campbell River	1874	✓	Х	Х	✓	Х	✓	\$2,000,000	Х	Х	N/A
Colwood	272	✓	✓	~	✓	$\checkmark$	✓	\$5,000,000	Х	✓	N/A
Highlands	67	✓	✓	✓	✓	Х	✓	\$2,000,000	Х	✓	\$5,000
Invermere	1346	✓	Х	Х	✓	Х	Х	\$5,000,000	Х	Х	\$10,000
Metchosin	230	✓	✓	✓	✓	Х	✓	\$2,000,000	Х	Х	\$5,000
Nanaimo	4750	Х	Х	Х	Х	Х	✓	Х	Х	Х	Х
North Cowichan	3255	✓	✓	Х	✓	$\checkmark$	✓	\$2,000,000	Х	Х	N/A
North Vancouver	2643	✓	Х	✓	✓	Х	√	\$1,000,000	Х	Х	\$200
Parksville	1432	Х	Х	Х	Х	Х	✓	Х	Х	Х	Х
Peachland	701	✓	Х	Х	Х	Х	Х	Х	Х	Х	\$1,000
Port Coquitlam	2961	✓	Х	✓	✓	Х	✓	\$5,000,000	Х	Х	\$2,000
Prince Rupert	2524	√	Х	Х	✓	Х	√	\$250,000	Х	Х	N/A
Rossland	2460	√	Х	✓	Х	$\checkmark$	√	\$2,000,000	Х	Х	\$5,000
Saanich	6821	✓	Х	Х	Х	Х	✓	\$2,000,000	Х	Х	> \$150
Sechelt	458	✓	✓	✓	✓	$\checkmark$	√	\$5,000,000	$\checkmark$	Х	\$10,000
Sooke	72	✓	Х	Х	✓	Х	✓	\$2,000,000	Х	Х	N/A
Squamish	188	✓	Х	✓	Х	Х	Х	\$1,000,000	Х	Х	N/A
Surrey	3551	√	Х	Х	Х	Х	Х	\$3,000,000	Х	Х	\$500
Terrace	1051	Х	Х	Х	Х	Х	✓	Х	Х	Х	Х
Victoria	06-008	✓	Х	X	✓	X	✓	\$5,000,000	X	Х	\$10,000
West Vancouver	4024	✓	✓	✓	✓	$\checkmark$	✓	\$5,000,000	$\checkmark$	Х	\$10,000
West Kelowna	71	$\checkmark$	Х	Х	✓	Х	Х	Х	Х	Х	Х

## Table 2: Summary of blasting related municipal bylaws in British Columbia



Good-Neighbour Bylaw

Noise Bylaw

Blasting Bylaw

Minimum insurance limits which protect the blaster against claims resulting in damaged property, personal injury or loss of life range from \$250,000 to \$5,000,000, with five municipalities not specifying a minimum limit. In the instance that a violation of a bylaw occurs, fines range from \$100 to \$10,000 for a first offence and ten municipalities do not specify a fine. Perhaps the most comprehensive bylaw in the province is the West Vancouver bylaw which has requirements for every sub-category in Table 2. The municipality of Sechelt has adopted West Vancouver's bylaw with only a few changes made to suit their district.

In summary, the bylaws that regulate blasting in British Columbia are sparse (23 of the 157 municipalities regulate blasting) and range from very poor, requiring only a permit without any regulations, to very extensive such as the blasting bylaws found in West Vancouver and Sechelt. Although these two municipalities' bylaws may seem very effective, it is felt by many blasters and consultants that some of the regulations are unnecessarily restrictive (T. Matts, pers. comm., July 28<sup>th</sup> 2011).

#### 3.3.2 Ontario

In Ontario, until amendments in 2001 to sections 8, 9, and 10 of the Municipalities Act, local governments had limited authority instilling bylaws such that they could not directly create or regulate a blasting bylaw (Gerresten, 2007). Therefore, unless a review of municipal bylaws was conducted in past 9 years, blasting regulations are limited to PPV and overpressure limits, and are governed under noise bylaws.

In the city of Hamilton-Wentworth, blasts must be monitored by the contractor, and the city retains the authority to require, at the owner's expense, the use of an independent engineer to monitor the blast; however it is on a site-specific basis (amended in 2010). However, specifications of PPV and overpressure are not specified (City of Hamilton, 2010). The township of Seguin has a blasting bylaw in place not to protect neighbours and surrounding structures from vibrations and overpressure, but to protect the visual and natural environment of the shoreline of lakes within the township (Township of Seguin, 2008). The city of Toronto regulates blasting by enforcing the inclusion of seismograph monitoring, which is to be monitored by a professional engineer (or someone acting on behalf of an engineer), and peak particle velocities are not to exceed those described in Table 3. As shown in Figure 4, these

limits are well below the safe PPV levels for residential homes. The cities of Ottawa and Windsor, had bylaws which attempted to regulate blasting within city limits, however both cities repealed them because it was too costly to effectively regulate blasting (Whitehouse, 2010b).

Prohibited Construction Vibrations				
Frequency of Vibration (Hz)	Peak Particle Velocity (mm/s)			
< 4	8			
4-10	15			
> 10	25			

Table 3: Maximum PPV limits for Toronto construction operations (City of Toronto, 2008)

Despite the absence of a municipal blasting bylaw, the overwhelming majority of vibration monitoring in the City of Ottawa is carried out by a qualified 3<sup>rd</sup> party monitor, monitoring every blast under the supervision of a professional engineer. The availability of a qualified blast monitoring consulting firm in the immediate area has drastically reduced blasting complaints without the need for municipal regulations. Blasters have realized that the cost of consultant retention outweighs the headache of frivolous complaints (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

#### 3.3.3 Nova Scotia

In August 2003, flyrock ranging in mass from pebbles to 150 kilograms flew 450 m from a blasting site and crashed into an occupied apartment building (Government of Canada, 2005). Just three months later, the most exhaustive and detailed blasting bylaw in Canada was passed (Halifax Regional Municipality, 2003). Halifax Regional Municipality Bylaw #B-600 is a 42 page document which outlines very strict requirements including: pre blast surveys to be conducted within a specified scaled distance from the blast site, monitoring of every blast by a professional engineer (or someone acting on behalf of the engineer), PPV limits well within the specifications set forth in Figure 4, overpressure limit equal to those set forth by MOE NPC-119, and other specific requirements. Perhaps one of the most interesting aspects of the permit application process is the inclusion of a \$5,000 deposit to be included in the blasting permit

application when the volume of rock to be blasted exceeds 50  $\text{m}^3$ . The intent of this security is to ensure that the blaster conforms to all regulations specified in the bylaw by opinion of the city inspector.

## 3.4 Regulations Stipulated by Blasters Insurance

Perhaps the greatest incentive to hire third party monitoring engineers is the threat of insurance not covering damage claims otherwise (R. Cyr, pers. comm., Nov. 22, 2010). Many insurance companies in Ontario who cover blasting corporations or individual blasters state that their insurance policy is void unless all blasting operations are monitored by an independent engineer. Blast monitoring expert Rob Cyr also investigated the state of practise in British Columbia and reports:

"I traveled to BC this summer to meet with various contractors and municipalities. . . what I learned was the contractors don't monitor because they aren't forced to and will not move on that until someone, or some event forces their hand. The municipalities don't have the expertise to establish [regulations] so they just don't bother" (R. Cyr, pers. comm., Nov. 22, 2010).

Insurance companies that provide liability insurance for blasters are the final regulating bodies to be considered. The insurer may require the blaster to retain, at the blasters expense, third party inspections (pre-blast surveys) and a consulting engineer for close-in blasting. Axa Insurance provides liability insurance for businesses, including blasting endorsements for contractors. The following is an excerpt from Axa Insurance Blasting Endorsement CGL-6 (0500):

## "IT IS HEREBY UNDERSTOOD AND AGREED THAT:

Damage to buildings, structures, work installations or bodily injury to persons within or on such property shall be excluded if said property is within 100 feet of any blasting operations or the use of explosives by or on behalf of the insured, unless specifically endorsed hereon.

**IT IS FURTHER UNDERSTOOD AND AGREED THAT** the insurer may extend this policy to include liability arising from the use of explosives by or on behalf of the Insured which would otherwise be excluded by the above conditions provided:

- the Insured shall submit full details to the Insurer prior to the commencement of blasting;
- the coverage provided by this Policy shall not be effective until the Insurer agrees to assume liability and such coverage is endorsed hereon; and
- *the Insured shall pay consulting engineering and prior inspection fees as may be required*" (AXA Insurance, 2011).

## 3.5 Brief Summary of Regulations in the United States

In the United States, a majority of state blasting operations are regulated by federal standards under the Occupational Safety and Health Administration (OSHA) (US Department of Labor, 2011a). Currently there are 22 states with "state plans," which regulate occupational health and safety independently from the federal government (US Department of Labor, 2011b). Of these 22 states, California and Washington are the only states with standards that differ from the federal regulations. Forty eight states regulate flyrock under the federal construction standard 1926.900(h) which states:

"When blasting is done in congested areas or in proximity to a structure, railway, or highway, or any other installation that may be damaged, the blaster shall take special precautions in the loading, delaying, initiation, and confinement of each blast with mats or other methods so as to control the throw of fragments, and thus prevent bodily injury to employees" (US Department of Labor, 1993).

Under the general industry provisions, there are also regulations which specifically aim to protect the general public. Under section 1910..109(e)(1)(iv), it states:

"Persons authorized to prepare explosive charges or conduct blasting operations shall use every reasonable precaution, including but not limited to warning signals, flags, barricades, or woven wire mats to insure the safety of the general public and workmen" (US Department of Labor, 1998).

The federal OSHA standards do not regulate vibration or overpressure.

## 3.5.1 California

In California, blasting operations are regulated under Article 116 of Subchapter 7 of the state OSHA regulations (Government of California, 2003). It is stated:

"(f) When blasting in a location where flying rock or material may damage other property or endanger employees, all loaded holes shall be covered with a blasting mat that has been anchored" (Government of California, 2003).

Vibration and overpressure are not part of California's occupational health and safety mandate.

#### 3.5.2 Washington

In Washington State, vibration, overpressure and flyrock are regulated under the Vibration and Damage Control subsection of the OSHA (Government of Washington, 2002). Vibration and

overpressure must be measured using a minimum of three seismometers in mutually perpendicular directions or using scaled distance equations which are provided in the state regulations. The blaster must comply with the maximum allowable vibration limits provided in Table 4 and maximum air blast limits shown in Table 5.

Table 4: Maximum allowable vibration limits for any structure near a blast in Washington(Government of Washington, 2002)

Peak Particle Velocity Limits				
Distance from blasting site	Maximum allowable peak particle velocity <sup>1</sup>			
0 to 300 ft (91.4 m)	1.25 in/s (31.75 mm/s)			
301 to 5000 ft (91.5 m to 1524 m)	1.00 in/s (25.4 mm/s)			
5000 ft (1524 m) and beyond	0.75 in/s (19 mm/s)			
<sup>1</sup> Peak particle velocity must be measured in three mutually perpendicular directions and the maximum allowable limits must apply to each of these measurements.				

Table 5: Maximum allowable overpressure limits for any structure near a blast in Washington(Government of Washington, 2002)

Air Blast Limits					
Lower Frequency of M	Measurement Level in dB(L)				
0.1 Hz or Lower	Flat Response	134 Peak			
2 Hz or Lower	Flat Response	133 Peak			
6 Hz or Lower	Flat Response	129 Peak			
C-Weighted	Slow Response	105 Peak			

Flyrock is regulated independently by the state; however the standards are very similar to the federal OSHA regulations. It is stated in the vibration and damage control section of Chapter 296-52-67065:

"(a) Uncontrolled flyrock. Flyrock traveling in the air or along the ground can't be cast from the blast area in an uncontrolled manner, which could result in personal injury or property damage. Uncontrolled flyrock (airborne or along the ground), that could cause personal injury or property damage, isn't allowed from the blast area (b) Contract or written waiver. Flyrock can't be propelled from the blast area onto property where the blasting operation has not contracted or received a written waiver from the owner (c) Use of protective material. When blasting in congested areas or close to a structure, railway, highway, or any other installation that could be damaged, the blast must be covered, before firing, with a mat or other protective material that will prevent fragments from being thrown" (Government of Washington, 2002).

## 3.6 Brief Summary of Regulations in Australia

Currently in Australia, occupational health and safety regulations are enforced at the state level with some variations in the regulations between states (Safe Work Australia, 2011). In order to avoid confusion, or accidental non-compliance when workers are licensed to work in more than one province, the Council of Australian Governments has decided to harmonize the health and safety laws, regulations, and codes and practices nation-wide so that they are the same in all jurisdictions. Each jurisdiction was required to enact these laws and reflect Safe Work Australia's model legislation by December 2011.

In the model legislation, there are no regulations specifically tailored to urban blasting. Blasting operations are considered a part of the umbrella category of "High-Risk Construction" (Safe Work Australia, 2010). Within this division, the workers are required to submit a "Safe Work Method Statement," which must:

"6.3.3 (2): (a) identify work that is high risk construction work; and (b) specify hazards associated with that high risk construction work and risks associated with those hazards; and (c) describe the measures to be implemented to control those risks; and (d) describe how the risk control measures are to be implemented, monitored and reviewed" (Safe Work Australia, 2010).

The precautions to be taken during urban blasting operations are left to the discretion of the blaster, which includes protection against flyrock, vibration and overpressure and all of the site-safety measures which are outline by WorkSafeBC. However, the government of Western Australia, for example, reserves the right to declare construction blasting as a "mining operation" if necessary, and therefore would adopt the prescriptive blasting regulations which are designed for the mining industry. It is stated in Part 1 (6) of the preliminary measures in the Mines Safety and Inspection Act that:

"(1) The Governor may, by order published in the Gazette, declare any surface or underground excavation, shaft, or tunnel constructed for purposes other than those set out in the definition of mining operations in section 4(1) to be deemed a mining operation for the purposes of this Act during any period of the construction of the excavation, shaft or tunnel" (Government of Western Australia, 1994).

In this instance, the blaster must then comply with the Mines Safety and Inspection Act at the urban blasting site which requires protection against flyrock, however there are no regulations which include vibration or overpressure. It is stated in section 8.30 (1) - (3) that:

"(1) If debris from blasting in a surface mining operation could constitute a danger to any person or property, each responsible person at the mine must ensure that such precautions are taken as are necessary to prevent injury to persons and to minimize the risk of damage to property. (2) If debris from blasting in a surface mining operation could constitute a danger to persons or if fly rock could land on public roads or property other than that of the principal employer, the manager of the mine must ensure that blasting mats are used and secured in a manner which will contain the debris during the whole blasting operation. (3) If the nature or extent of any blasting at a mine is such that blasting mats may not be effective, the manager of the mine must ensure that the blast design (including charge distribution, stemming length and type and delay sequence) is such as to minimize the risk of fly rock" (Government of Western Australia, 1995).

## **3.7** Comparison of BC Regulations to Other Canadian Provinces, US and Australia

The adverse environmental effects of blasting including: flyrock, vibration and overpressure were evaluated from a regulatory standpoint in Canada, the United States and Australia.

## 3.7.1 Flyrock

In all countries investigated, if flyrock is regulated, it is a state or provincial-wide law. In all cases, the use of blasting mats is left to the discretion of the blaster (i.e. *blasting mats must be used, where necessary, to prevent flying objects etc.*). The flyrock regulations are intentionally written in this manner to avoid over-regulation and to download the risk of indecision to the blaster. A major discrepancy between British Columbia and the rest of Canada is that in British Columbia, it is the blasters, rather than the employer that is responsible for ensuring that discharge of flyrock does not occur in order to avoid suspension of their blasting ticket, and/or potential fine/prosecution. That being said, it is the blasters in BC, rather than the company that is penalized for flyrock incidents/accidents. As shown in Table 1, nearly every province stipulates that "an employer and blaster must ensure necessary precautions are taken . . ."

whereas in British Columbia, Part 21.66 (1) of the OHS Act states that "the blaster must take precautions..." (WorkSafeBC, 2010).

#### 3.7.2 Vibration and Overpressure

Vibration and overpressure as a result of urban blasting, which are the root of most complaints made by concerned neighbours, are poorly regulated in all jurisdictions. Using the same vague nature as the provincial and state regulations for flyrock, Nova Scotia and Newfoundland require the blaster to take *necessary* precautions to ensure the adverse effects of vibration and overpressure are minimized. However, these regulations are subjective and lack prescriptive limits. Washington State, on the other hand, has implemented state-wide limits for vibration and overpressure that are consistent with the National Fire Protection Association (NFPA) Standard 495.

In British Columbia, and nearly all other provinces / states, overpressure is not regulated for urban blasting, and requirements for vibration monitoring are rare. In Ontario, there are fewer municipal regulations that require blast monitoring, than in British Columbia, however there is more self-regulation due to blasters retaining a third party blast monitoring/consulting firm with a proven cost advantage.

## 3.8 Summary

The federal government has a strict set of guidelines and regulations that are directly related to the safety and security of manufacturing explosives, their storage, import and transportation into and within the country (Natural Resources of Canada, 2010).

Provincially, WorkSafeBC outlines best practices for blasting to ensure the safety of employees on the construction site, and the Ministry of Mines regulates similar laws and regulations, in addition to the safety of persons and property that neighbour mines and quarries.

There are very few regulations in British Columbia that protect the neighbours and their property from urban blasting and most municipalities have none at all.

A summary of the various regulating bodies, their jurisdiction, and extent of regulations discussed is provided in Figure 7. Only 2% of the BC population lives within a jurisdiction that requires blasters to monitor the blast with a seismometer. When a complaint is made, the

neighbour will often call the city, of which 136 out of 157 municipalities may be unaware that blasting is occurring (due to lack of regulations / permit process), and the dispute resolution is complicated by lack of vibration / overpressure evidence.



Figure 7: Gaps in regulatory control for vibration and overpressure in British Columbia

## **4** Flyrock Incident Reduction

The intention of this chapter is to identify a mitigation technique that reduces the number of flyrock incidences in British Columbia. Provincial incident reports were obtained from the Freedom of Information offices in Ontario and British Columbia and the underlying causes of flyrock were documented. A comparative analysis between incidents in the past decade and the differences in flyrock regulatory control between the two provinces were used to identify a mitigation measure. Finally, interviews with blasting contractors, consultants and provincial regulators complimented the comparative analysis.

## 4.1 Incidents / Accidents in Canada

Through personal communication and publicly available information on provincial occupational health and safety websites, flyrock incidents and accidents were investigated. Unfortunately this procedure required three months of censorship and bureaucracy within the various Freedom of Information & Protection of Privacy offices. In British Columbia, Ontario, and Yukon Territory, every flyrock incident that was reported to the respective authorities between 2001 and 2010 are provided. All other provinces and territories were unresponsive, and only those incidents that were reported in newspapers are recorded.

#### 4.1.1 Ontario

In Ontario, flyrock is regulated by the Ministry of the Environment. All reported flyrock incidents that occurred in Ontario between 2001 and 2010 are provided in Table 6. In every instance, the blasters were fined between \$2,500 and \$35,000 depending on the severity of the incident and the size of the company (Ontario Ministry of the Environment, 2008a, 2008b, 2008c, 2009, 2010).

#### 4.1.2 British Columbia

In British Columbia, flyrock is regulated by WorkSafeBC. All reported flyrock incidents that occurred in British Columbia between 2001 and 2010 are provided in Table 7. Of the 26 incidents described, there have only been two blasting companies that have been fined, which occurred when there was a repeat offence (WorkSafeBC, 2009b).

# Table 6: Flyrock incidents in Ontario (Ontario Ministry of the Environment, 2008a, 2008b,2008c, 2009, 2010)

Date	Location	Incident
August 2009	Chelmsford	An inexperienced blaster detonated a blast using a single stick of dynamite that caused flyrock to project approximately 33 m onto adjacent private property.
November 2007	Marmora	Flyrock penetrated the roof, damaged the eaves and sidings, and entered a kitchen of a residential home.
August 2007	Braeside	Flyrock damaged a home and vehicle parked in the driveway.
August 2006	Bracebridge	Flyrock shower sent nearby resident running for cover. Flyrock about the size of a softball landed on his lawn.
August 2004	Hamilton	Flyrock showered a residential area. Rock went through the roof of a home, and damaged two vehicles.

Date	Location	Incident
October 2009	Central Interior	Traffic control person struck 45 m from blast site.
June 2009	Central Interior	Flyrock thrown more than 100 m into surrounding homes
February 2009	Lower Mainland	Flyrock struck homes and put numerous workers at risk
September 2008	Lower Mainland	Flyrock struck nearby homes and vehicles of a blast
September 2008	Lower Mainland	During road construction, flyrock from a blast struck homes
August 2008	Lower Mainland	Flyrock flew 75 m into homes and vehicles
June 2008	Central Interior	Blast lifted overburden and blast mats 30 m into the air, adjacent building was struck
June 2008	Central Interior	Flyrock ejected 75 m from the blast site striking homes and a parked car
May 2008	Central Interior	Flyrock from a blast damaged several nearby homes
April 2008	Lower Mainland	Flyrock resulted from a blast that misfired
December 2007	Vancouver Island	Flyrock covered 4 cars in dust and small particles at a residential area near the blast
July 2007	Vancouver Island	Workers received minor injuries from flyrock
May 2007	Lower Mainland	Flyrock from a blast took out overhead power lines
March 2007	Lower Mainland	Flyrock struck a house across the highway from a blast site
January 2007	Vancouver Island	Numerous flyrock incidents occurred at a Sechelt jobsite. In one incident, rock went through a residential roof.
October 2006	Central Interior	Flyrock landed in the yard of a house
August 2006	Central Interior	Flyrock struck several private vehicles and a bridge pier
May 2006	Central Interior	Flyrock blast flew 150 m damaging a sundeck
May 2006	Central Interior	Flyrock damaged a home and scattered material over a public roadway
February 2005	Lower Mainland	Flyrock escaped from blast mats and travelled 60 m onto private property
February 2005	Lower Mainland	Flyrock from a blast site struck nearby homes
June 2004	Central Interior	Flyrock damaged nearby homes
January 2003	Central Interior	Flyrock damaged the roof of a covered deck off site

## Table 7: Flyrock incidents in British Columbia (WorkSafeBC, 2009a)

## 4.1.3 Yukon Territory

On May 6<sup>th</sup> 2008, flyrock ranging from small pebbles to 22 kilogram boulders rained down on a trailer park in Whitehorse, Yukon Territory (Canadian Press, 2010). The rocks were launched up to 140 m from the blast site and destroyed a shed, crashed into living rooms of occupied trailers (as seen in Figure 8), and sent one tenant running for his life (Davidson, 2010).



Figure 8: A tenant observes parts of her living room which were destroyed by a rock shower caused by irresponsible blasting practices (Davidson, 2010).

The proceedings from the trial revealed one of the major causes of the blaster's irresponsibility, in addition to the poor blasting practices which resulted in flyrock to be thrown such a great distance.

"It wasn't until 'well after" the May 6 blast that Hildebrand [the blaster] ever saw a map showing the distance between the boulevard extension and the homes. 'I have no hesitation in finding that both Sidhu Trucking and Mr. Cratty failed in their duty because they did not ensure that Mr. Hildebrand was properly oriented to the site so as to be aware of the close proximity of persons or property likely to be affected by the blasting operations,' Faulkner [the judge] wrote. 'Moreover, blasting is an inherently dangerous undertaking, and it would be common sense to be well aware of the distance to persons or structures -- especially in an urban area'" (Canadian Press, 2010). It is clear that the blaster had no understanding of the location of the neighbours to his blast site. It is also safe to assume that the accident could have been avoided, using industry-accepted practices, if the location of those homes were clear to the blaster.

According to the Director of Occupational Health and Safety for Yukon's WCB, this is the only flyrock incident in the past 10 years (K. Dieckmann, pers. comm., June 20<sup>th</sup> 2011).

#### 4.1.4 Nova Scotia

Flyrock ranging from pebbles to 150 kilograms flew 450 m from the blasting area and crashed into an occupied apartment building in mid-August 2003. Just three months later, the most exhaustive and detailed blasting bylaw in Canada was passed (Halifax Regional Municipality, 2003).

#### 4.2 Causes of Flyrock Incidents and Accidents

Between British Columbia, Ontario, Yukon Territory and Nova Scotia, there were 31 reported incidents of flyrock between 2001 and 2011 and the causes are shown in Figure 9. The information provided in Figure 9 is extracted from incident reports provided by WorkSafeBC, the Ontario MOE as well as factual information given in newspapers from the Yukon Territory and Nova Scotia.

It is important to note that the data collected from the MOE and WorkSafeBC, are only those reported flyrock incidents. The automatic \$25,000 fine that is imposed to Ontario blasters could very well deter the number of incidents reported to the Ministry, by the blaster, especially if there is no harm done.

A summary of detailed incident reports from Ontario MOE and WorkSafeBC are provided in Appendix B. Thirteen of these flyrock incidents were a result of a poor blast design including (i) the quantity of explosives used was excessive relative to volume of rock blasted, (ii) loaded blast holes intersected shear holes, (iii) improper detonation sequencing, (iv) blaster unaware of location of homes, and (v) the depletion of a protective rock berm. Three flyrock incidents were caused by a misfire which is essentially an explosive charge that fails to detonate in the planned manner (ISEE, 2011). Two incidents were a result of failure of the initiation systems, and the other was a cut off between the second and third rows of blast holes.



Figure 9: Causes of 31 reported incidents of flyrock in Canada

The number one cause of flyrock in Canada between 2001 and 2010, accounting for 45% of the flyrock incidents, was the improper use, or absence of blasting mats to contain the blast. Eleven of the 31 incidents were the result of blasting without blasting mats when homes were in close proximity (some documented distances include: 90 m, 90 m, 100 m, 100 m, and 150 m). In addition, three of the 31 incidents were the result of improper placement, where flyrock escaped the mats. There was one incident where the cause of flyrock was not documented.

## 4.3 Comparative Analysis of Incidents and Complaints Versus Regulatory Control

To analyze the effectiveness of blasting regulations in Canada, the provinces with the most data (BC and ON) have been chosen for a comparative analysis of flyrock incidents versus regulatory control. The causes of flyrock are compared alongside the respective regulations that are associated with these incidents.

The causes of the 31 flyrock incidents that were analyzed Canada-wide (shown in Figure 9) have been broken down into British Columbia and Ontario incidents in Figure 8 and Figure 9 respectively.



Figure 10: Causes of 6 reported incidents of flyrock in Ontario between 2001 and 2010

There have only been six reported flyrock incidents reported in Ontario between 2001 and 2010. Every one of these incidents was preventable as five are attributed to poor design, and one case was the result of the absence of blasting mats.

In Ontario, flyrock is regulated by both the Ministry of Labour and the Ministry of the Environment. As previously discussed, for construction blasting, the Ministry of the Labour requires blasting mats to be used to protect persons or property adjacent to the site. However, unlike the province of British Columbia, the Ministry of the Environment also regulates the discharge of flyrock which is labeled a contaminant. If a blasting contractor discharges flyrock off site, the company is automatically fined \$25,000. Some fines are reduced based on the size of the blasting company and their insurance policy etc.



Figure 11: Causes of 23 reported incidents of flyrock in British Columbia between 2001 and 2010

The number of flyrock incidents in British Columbia is much higher than in Ontario between 2001 and 2010. It is not possible to stipulate whether or not British Columbia has a higher incidence rate than Ontario because the number of urban blasts per year in both provinces is unknown. However, of the 23 reported incidents of flyrock in an urban setting, a majority of them (57%) are caused by the absence of, or misuse of blasting mats. Of these incidents, at least 87% were preventable with better blasting practices. There is not enough detail in the incident reports provided by WorkSafeBC to determine whether or not the three misfires in British Columbia were preventable.

In British Columbia, flyrock is regulated by WorkSafeBC. As previously discussed, WorkSafeBC requires the blaster to use blasting mats *"when necessary,"* to protect persons and property adjacent to the site. In addition, three incidents were caused by an absence of blasting mats, and all three incidents occurred in municipalities that specifically require the use of blasting mats. It is clear that neither the provincial WorkSafeBC regulation, nor flyrock-related clauses in municipal bylaws are effectively regulating the issue.

Regardless of the number of urban blasts that have been detonated in the past 10 years in British Columbia and Ontario, it is clear that the percentage of flyrock incidents caused by an absence of blasting mats or improper use of blasting mats is significantly greater in British Columbia. The fundamental difference between Ontario and British Columbia provincial flyrock regulations is that:

- Ontario Ministry of the Environment fines the blasting company for every single flyrock incident, regardless of the cause.
- WorkSafeBC penalizes the individual blaster.

## 4.4 Interview / Discussions with WorkSafeBC Representative, Blasters and Consultants

The comparative analysis between flyrock incidents and accidents in British Columbia and Ontario and their respective regulations, suggests that more fines and/or a regulation amendment can reduce the number of flyrock incidents. Furthermore, to hold the blasting company, not just the individual blaster, accountable for flyrock, and imposing fines on every occurrence improves urban blasting practices.

However, as previously discussed, the reported incidents of flyrock are likely not representative of the actual number of incidents. In order to further analyze the causes of flyrock incidents and suggest an appropriate mitigation tactic, all preceding research was presented and discussed in an interactive forum at the Western Canada Chapter of International Society of Explosives Engineers' annual general meeting in Vernon, BC on October 16<sup>th</sup> 2011. This annual conference included 36 blasters, consultants, explosives providers, WorkSafeBC representatives, Ministry of Mines representatives and many other stakeholders of the industry. Specific recommendations were made by attendees and are these summarized below. The participants that provided feedback include:

- Ron Elliott (Blasting Contractor) Pacific Blasting & Demolition Ltd.
- Jim Launay (Blasting Inspector) WorkSafeBC
- Alastair Grogan (Blasting Consultant) Grogan Rock Consulting Ltd.

Suspicions regarding the lack of reporting, and the root causes of flyrock incidents in British Columbia were confirmed by discussions with the conference attendees. A transcript of their response to all preceding research regarding flyrock is provided below:

## Alastair Grogan:

"Flyrock incidents in Ontario are probably just not being recorded. The fine is for flyrock leaving a property onto another property. Often that is not seen and the evidence would be swept off the street. I would strongly suspect that several flyrock incidents in Ontario are not recorded. I think in BC the flyrock incidents are recorded because there's an incident" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

## Ron Elliott:

"I think that a lot of the flyrock incidents that occur are due to faulty blast designs to start with, the blaster's blast design should control flyrock and the blasting mats should be a secondary measure. Where blasters get in trouble, are when blasters have faulty blast designs and try to use the blasting mats to control the flyrock and as soon as the mats open up, you've got a flyrock incident. A lot of it relates back to a blaster not being trained on how to do a proper blast design in the first place" (R. Elliott, pers. comm., October 16<sup>th</sup> 2011).

## Alastair Grogan:

"Some contractors, they will factor into their price, the cost of paying out damage claims. Their insurers never hear about it. The insurance company never has to pay a dime" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

## Ron Elliott:

"I don't think imposing higher fines is the answer. You have to look at what is the cause of the problem and go after the cause. They will just include that in their price to do the job" (R. Elliott, pers. comm., October 16<sup>th</sup> 2011).

## Alastair Grogan:

"Many times there is a flyrock incident, the blaster gets fined the company fires the blaster and hires a new one. The blaster always fronts the penalties and the blasting companies don't care" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

## Jim Launay:

"I think that anybody who is involved in the blasting process should be held accountable. Some companies have flyrock incidents. In one instant, I have watched that rotating door where they fired the blaster and get another one." (J. Launay, pers. comm., October 16<sup>th</sup> 2011).

It is the general consensus among blasters, consultants and inspectors alike, that blasting companies are not taking the necessary precautions to prevent flyrock, and are pushing the blasters to conduct their work too cheaply. This in turn causes larger holes, wider spacing on blast hole patterns, and less regard for safety from flyrock. Due to the manner in which the regulations are written, the blaster is essentially a scapegoat, and the company simply hires a new blaster and continues business as usual.

## 4.5 Recommendations

It is recommended that flyrock remain the mandate of the provincial government. In addition, municipalities should refrain from stipulating that blasting mats should be used for all blasts, as this would expose the municipality to unnecessary risk as compliance with the provincial government regulations already account for this.

Currently, the Ontario Ministry of Environment holds both the blaster and the company responsible by specifically stating:

"Subject to subsection (2) [Unless otherwise authorized] but despite any other provision of this Act or the regulations, a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect" (Ontario Ministry of the Environment, 1990).

Nearly all other provinces in Canada, shown in Table 1, also hold the blasting company accountable by stating:

"An employer and blaster must take precautions..."

It is recommended that WorkSafeBC makes an amendment to their current Part 21.66 (1) of the OHS Regulations. The current manner, in which the regulation is written, may only hold the blaster accountable for a flyrock incident:

"21.66 (1)The blaster must take precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material" (Work Safe BC, 2010).

It is concluded from the data, and confirmed by opinions of blasters, consultants and WorkSafeBC blasting inspectors alike, that the inability to link the company to the incident is

one of the underlying causes of flyrock. Blasting companies keep their operational costs low by firing blasters, after an incident, and picking up a new one.

The regulation must be re-written, in order to hold the employer accountable for incidents and accidents that the company causes. WorkSafeBC should amend their current regulation in the following manner:

21.66 (1) An employer and blaster must ensure that a blast is not fired until the necessary precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material have been taken.

WorkSafeBC should also consider taking a similar approach to Ontario's MOE, and fining the company any time that there is a flyrock incident.

## 5 Vibration, Overpressure and Other General Complaint Reduction

Vibration and overpressure, unlike flyrock, is an unavoidable adverse environmental effect of blasting. Complaints lodged to municipalities, as a numerical estimation made by municipal engineers across British Columbia, were tabulated and compared with existing blasting bylaws within their jurisdiction. A blasting bylaw, identified as the most appropriate means of vibration and overpressure mitigation, was developed that includes proven effective regulations, and an informative pamphlet to educate affected homeowners about the blasting industry. Finally, in order to reduce the impact on blaster productivity, extensive input to the wording in the bylaw was gathered from blasting contractors and consultants across the country.

## 5.1 Incidents and Complaints

Mitigation techniques can only be used to minimize vibration and overpressure rather than completely eliminate them. After speaking with municipal engineers at six municipalities in British Columbia, it was found that vibration and overpressure are the root cause of nearly all complaints. However, since regulations requiring blast monitoring are sparse, there is little to no publicly available data nation wide. Vibration, overpressure and other general blasting related complaints in Canada were analyzed from newspapers nationwide and through meetings with municipal engineers and inspectors across British Columbia.

#### 5.1.1 Ontario

At least 37 neighbours of a proposed Wal-Mart foundation excavation in Sudbury pursued a class action lawsuit against a blasting contractor for their complete disregard for the surrounding community (Whitehouse, 2010a). The most common complaints were cosmetic damage including but not limited to: cracked drywall, cracked concrete foundations, shifted doors and windows and damage to driveways. Due to a lack of regulations, there was no incentive for the blasting contractor to hire third party monitoring, pre-blast surveys were not performed and the blasting company monitored the blast themselves: leaving a bias in the data, which was very poor and inconclusive. An independent engineer investigated the matter; however without sufficient data, including a concise record of blast logs, location of monitoring equipment, and

detailed peak particle velocity recordings, it was difficult to legally stipulate the source of the damage. This makes the process of rectifying the issue very slow, which in turn causes increasing concern from the community.

In the case of the Sudbury class action suit against a blasting contractor, many community complaints were directed to the MOE, however they were continually redirected back to city officials (Whitehouse, 2010b). This resulted in "years of backroom bickering [between the city and] the Ministry of the Environment," and still has yet to be resolved. In one letter which was sent from the Minister of the Environment, John Gerresten, to the Mayor of Sudbury John Rodriguez, it was made very clear that construction blasting related issues fell under the jurisdiction of the City of Sudbury. The minister clarifies:

"It remains outside the MOE's mandate to regulate commercial/residential development activities that are permitted through the municipal planning process or by the issuing of a building permit. The current blasting policies and guidelines that the Province is authorized to approve deal primarily with activities such as mines, pits and quarries. The MOE has no approval requirements for most municipal activities related to residential and commercial development" (Gerresten, 2008).

Rob Cyr, a blasting engineer with Explotech Consultants, expressed his concern with projects like this where a consultant is not retained. He stated that the difficulty with resolving these issues is that, in his opinion, a majority of the damage claims were not the result of blasting. The damage claimed to be a result of blasting typically was pre-existing, however due to the absence of regulations requiring blast monitoring and/or pre-blast surveys, proving this in court becomes much more difficult (R. Cyr, pers. comm., November 22<sup>nd</sup> 2010). Rob Cyr is now working alongside a panel of stakeholders toward developing a blasting bylaw for the city of Sudbury (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

#### 5.1.2 British Columbia

Another common, but reasonable complaint made by nearby residents of a blast site is poor warning or notification of blasting prior to the commencement of blasting. The district of West Kelowna posted a bulletin stating:

"The District has received a number of complaints regarding the blasting in the area for the development of Phase 9 Smith Creek Hills on Asquith Road, indicating concerns for the size of blasts, vibration, lack of warnings and potential damage to homes" (District of West Kelowna, 2010a). In response to these complaints, the district of West Kelowna developed a section of blasting regulations under the Good Neighbour Bylaw – No. 0071.02 (District of West Kelowna, 2010b). Section 2.9 of this bylaw, which was added on November  $23^{rd}$  2010, states that:

"The holder of a Blasting Permit may not commence or allow blasting or blasting operations until such time as the holder of the Blasting Permit has given notification to the neighbourhood as required by the terms of the Blasting Permit and as required by the communications plan, as approved by the Director of Engineering or the Director of Building and Regulatory Services who issued the Blasting Permit" (District of West Kelowna, 2010b).

In December 2010, a few weeks after the implementation of this bylaw, concerns arose during blasting when blasters knocked at the door of Mike McVicar's house to inform him of a blast that was about to go off. However he was unable to immediately answer the door, "when I got out of the shower I went outside and sure enough they were prepared to blast... there were guys on the hill telling me to move out of the way because they are going to blast." He asked "why?" The blaster responded, "because it's dangerous" (Moore, 2010). Although Bylaw No. 0071.02 stipulates communication of blasting procedures to neighbours of a blast, it is clearly not satisfying the communities' wishes.

Vibration and overpressure complaints were investigated through personal communication with municipal engineers and building inspectors as summarized in Table 8.

		PPV		
Municipality	Incidents	Measured	Other Comments	Source
		(mm/s)		
District of Highlands	One neighbour was a constant complainant of vibration due to blasting at a golf course.	4	"I have found that almost 100% of the complaints to be unsubstantial. It is a really misunderstood field it is more about educating the public."	(C. Leeks, pers. comm., July 27 <sup>th</sup> 2011)
Nanaimo	In a message recorded for the City Engineer it states: "A woman very frightened by the blasting activity [near her home] and is concerned regarding damage as there is a lot of interior movement within her house."	< 26	"It's an education thing, a lot of people do not understand that when blasting goes off – it's the overpressure that is shaking their house and because of this, we are going to get some complaints. A lot of it is educating people on what to expect." Highest PPV the city engineer has seen: 26 mm/s	(D. Mousseau, pers. comm., July 27 <sup>th</sup> 2011)
Kelowna	"One complainant is suing a neighbour for damages due to vibration"	< 1	"It's all related to vibration, shaking things off they're shelves, cracking windows."	(S. Muenz, pers. comm., June 22 <sup>nd</sup> 2011)
Sechelt	"Blasting operations were conducted throughout 2007 at a residential development project [that] resulted in numerous complaints from residents regarding the blasting safety, blasting damage, and noise created in their neighbourhood." <sup>1</sup>	> 50 at time of incident < 50 after bylaw imposed	"We want the blasting company to notify the surrounding area." "I think a PPV of greater than 50 mm/s did come up in the trail bay estates [before bylaw imposed]" <sup>2</sup> "We haven't had too many complaints since 2007 [when the bylaw was imposed]" <sup>2</sup>	<sup>1</sup> (WorkSafeBC, 2007) <sup>2</sup> (K. Tang, pers. comm., July 28 <sup>th</sup> 2011)
West Vancouver	"The most common complaints are noise."	< 50	"We have never had a PPV limit over 50 mm/s"	(T. Tse, pers. comm., July 28 <sup>th</sup> 2011)

## Table 8: Vibration and overpressure complaints in British Columbia

## 5.2 Comparative Analysis of Incidents and Complaints Versus Regulatory Control

Vibration and overpressure regulations are as sparse and difficult to find as documented complaints in both British Columbia and Ontario. As shown in Figure 7, only 2% of the British Columbia population is protected by a municipal regulation that requires the blaster to monitor vibrations, and no municipality regulates overpressure. In Ontario, the City of Toronto regulates

vibration and overpressure for all construction activities (which blasting falls under). The effectiveness of this general regulation is unknown.

The effectiveness of municipal bylaws can be deduced from Table 8. In West Vancouver, which has one of the most exhaustive bylaws in Canada, there has never been a PPV recording exceed the 50 mm/s limit (T. Tse, pers. comm., July 28<sup>th</sup> 2011). The municipality of Sechelt adopted West Vancouver's bylaw in the middle of a project, after PPV were recorded exceeding 50 mm/s. Once the bylaw was implemented, there has never been a PPV recording that exceeded the 50 mm/s limit (K. Tang, pers. comm., July 28<sup>th</sup> 2011).

It is clear that these prescriptive bylaws are effective; however complaints are made regardless of the magnitude of PPV. In the City of Kelowna, a lawsuit is currently underway between a concerned neighbour and a blasting contractor over cracks that were claimed to have developed during a blast (S. Muenz, pers. comm., June  $22^{nd}$  2011). When monitoring equipment was moved to the home during a similar blast, PPV recordings showed values of < 1 mm/s.

This particular incident is an excellent example of the problem that unregulated municipalities face. Due to the absence of regulations requiring blasters to set up seismometers and monitor the blast or conduct pre blast surveys, there is no evidence to easily dismiss allegations of damage due to blasting. As previously discussed, a blasting contractor in Sudbury experienced this dilemma in a class action lawsuit with several complainants. The City of Sudbury is currently working towards implementing a blasting bylaw (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

However, lack of monitoring is not the only issue surrounding vibration and overpressure complaints. The other contributing factor is the general public's lack of blasting knowledge, and the absence of regulations requiring blasters to establish effective communication with the affected public (District of West Kelowna, 2010a). Table 9 summarizes the evidence of the need for an educational program for neighbours of blast sites.

Municipality	Comment	Source
District of Highlands	"I have found that almost 100% of the complaints to be unsubstantial. It is a really misunderstood field it is more about educating the public."	(C. Leeks, pers. comm., July 27 <sup>th</sup> 2011)
Nanaimo	"It's an education thing, a lot of people when blasting goes off – its the overpressure that is shaking their house and regardless we are going to get some complaints. A lot of it is educating people on what to expect."	(D. Mousseau, pers. comm., July 27 <sup>th</sup> 2011)
Sudbury	The difficulty with resolving these issues is that, in his opinion, a majority of the damage claims were not the result of blasting.	(R. Cyr, pers. comm., November 22 <sup>nd</sup> 2010)

#### Table 9: Summary of evidence of the need for an educational program

It is proposed that the negative environmental effects of vibrations and overpressure can be further mitigated, beyond "best-practices" approaches by establishing an early positive relationship with the neighbours of a blast site, and an open communication flow between the public and the blasting contractor. This education and communication plan, coupled with an appropriate bylaw including monitoring and/or pre-blast survey specifications will reduce the number of blasting-related complaints in British Columbia.

## 5.3 Alleviating Neighbours Concerns with a Public Relations Plan

There is a consensus among blasters, consultants, and municipal engineers that a majority of complaints are frivolous due to the affected neighbour's lack of blasting understanding. There has been extensive research showing the effectiveness of complaint reduction using a blasting education / public relations plan, prior to blasting (Sanders and Luchansky, 2000). The intention of a communication bridge between the blaster and the affected neighbours is not only to warn the citizens of blasting in the area, but more importantly to educate the home or building owners as to what to expect when a blast occurs (Penttinen, 2005). A literature review was conducted to determine best practice procedures for site-neighbour communication and the key points that should be addressed.

## 5.3.1 Rational and significance

As previously discussed, the negative relationship between blasters and surrounding residents is often due to a lack of blasting knowledge. In a study conducted by Ziegler (2000) it was found that:

"Blasters are sometimes too quick to believe that a property owner is 'just trying to get something for nothing.' Although this may occasionally be true, our findings and beliefs are quite the opposite: most damage claims come from people who honestly and truly believe that they have suffered damage. . . a majority of investigations find evidence that the condition(s) were pre-existing" Ziegler (2000).

The general public lack the base knowledge and understanding of blasting practices, which results in complaints to blasting contractors and draw negative attention to the blasting industry. People will likely complain if they:

- 1. Feel an objectionable level of vibration,
- 2. Hear an intolerable level of noise,
- 3. See "damage" due to vibration or overpressure,
- 4. See flyrock which has been launched onto their property.

The first three points are inter-related and it is proposed that a detailed public relations plan which educates the neighbours of blasting procedures will significantly reduce such complaints. The final point regarding flyrock, on the other hand, is a result of unsafe blasting procedures and it is proposed that educating the neighbours of this fact will in turn:

- Increase the integrity and validity of the information, showing the neighbour that the blasting information is unbiased;
- Provide the neighbours with a complaint mechanism to report flyrock (telephone number to the blasting department at WorkSafeBC) since it is a violation of Section 21.66 (1) of the OHS Act (WorkSafeBC, 2010).
- Increases the accountability to the blaster to ensure safe practices are being followed and the chances of flyrock are minimized.
- Assuming that the communication is done door-to-door, the blaster (or someone working on their behalf) will gain detailed knowledge of the proximity of the neighbours to the blast site.

In order to maximize the positive response from this transfer of information, it is important to first establish the necessary points to be communicated, and then identify the most effective means to convey the information.

## 5.3.2 Key points in a communication plan

It is proposed that the number of vibration, overpressure, flyrock and "damage" complaints can be reduced if the following key items are relayed, in layman's terms, to people around the blast site:

- Project specific information
- Information about acceptable vibration and noise levels
- Information about how vibration and noise can be monitored
- What to watch for regarding flyrock
- Permits and regulatory oversight
- Qualifications of the blasters
- Experience and approach with blasting near structures
- Site geology and response of structures
- Pre-blast surveys

## 5.3.2.1 Project specific information

To inform people of upcoming blasts in their neighbourhoods, it is important to provide them with project-specific information. The following is a list of common discussion points (Murray and Bender, 1988):

- *Brief description of the project* It is likely that the resident or structure owner is already aware of the project which is underway close to their home. However, a description of blasting practices and a reason for blasting can be provided.
- *Blasting safety procedures and signals* Affected neighbours should know the safety procedures, and the meanings of sirens or signals used on a blast site. In British Columbia, Section 21.69 of the OHS Act states (WorkSafeBC, 2010):
  - (1) (a) preceding the blast, 12 short whistle signals must be sounded at one second intervals;

- (1) (b) two minutes must elapse after the last warning signal before initiating the blast;
- (1) (c) following the blast and after the area has been inspected and found safe, one prolonged whistle signal of at least 5 seconds duration must be sounded, to signify that permission is granted to return to the blasting area.

(3) Subsection (1)(b) does not apply with respect to the 2 minute warning in congested areas if alternative warning procedures acceptable to the Board are developed and implemented.

Regardless of the procedures which are used, whether Section 21.69 (3) applies or not, the blasting signals must be conspicuously posted at the blasting operation (WorkSafeBC, 2010). Additional safety procedures may include blasting mats, which are used to protect flyrock occurrences, and traffic changes within the boundaries of the specified danger zone.

- Scheduled blasting times The information, provided to nearby people, gives a sense of security and minimizes the alarming nature of the disturbance (Penttinen, 2005). Intuitively, it must also be emphasized that the blasting may be delayed or conducted at other times due to blasting safety, such as threats of lightening.
- Names and phone numbers of persons to contact for questions, concerns, problems, or to report flyrock (WorkSafeBC) It is important that the person(s) investigating damage claims is a consistent, and competent individual (Murray and Bender, 1988).

## 5.3.2.2 Vibration

Intuitively, the means in which vibration is measured is the first topic to discuss with a neighbour. Zeiglar (2000) provides an excellent definition of PPV in layman's terms for the inexperienced individual:

"For ground vibration, the characteristic used for evaluation is the Peak Particle Velocity (PPV). The principle factors which determine PPV are charge weight per delay and distance from the blast site to the structure in question" Zeiglar (2000).

"Charge weight per delay" is the amount of explosives simultaneously detonated at any point in time (ISEE, 2011). Since the distance between the blast site and the structure is fixed, two conclusions can be relayed to a concerned neighbour:

- 1. The amount of explosives detonated at an instance in time is managed to ensure safe vibration limits at the closest structure,
- 2. If applicable, a seismometer will monitor these vibrations at the closest structures to the blast. It may be concerning to someone that their home is not being monitored while seismometers are placed at another person's home. However, people may be unaware that if they are further from the seismometer, with respect to the blast site, the vibrations will attenuate.

Zeiglar (2000) also goes on to clarify the units in which PPV is measured, which are often misunderstood and can lead to unnecessary concern:

"The velocity measurement of PPV is commonly referred to as "inches" (of vibration level). It is essential to understand that this is not how much the ground moves (displacement), but rather, how fast it moves. In most situations the amount of displacement is a few thousandths of an inch or less, this being an elastic response with no net displacement. '2 inches' [50 mm] sounds like a large amount, because most people envision 2 inches [50 mm] of motion. For persons not acquainted with the concept of PPV, a seismograph demonstration often helps place a realistic perspective on the force which 2.0 IPS [50 mm/s] represents" Ziegler (2000).

If people are made aware of the instrumentation, and the PPV measured which it obtains, it is then necessary to provide them with the jurisdiction's acceptable limit, and the point at which damage may occur. It is then imperative to compare these values to household activities or environmental changes with which they are much more familiar.

Although municipal or provincial regulations may not stipulate a specific limit for PPV (as is the current case in British Columbia with the exception of West Vancouver), the U.S. Bureau of Mines recommended PPV level is 2.00 IPS (50 mm/s) for frequencies of greater than 40 Hz (Zeiglar, 2000), which is often the adopted regulated value for most municipalities, including the District of West Vancouver (District of West Vancouver, 1996) which is regulated independent of frequency. Further, it is recommended "best-practice" by the International Society of Explosives Engineers (2011), that the limit of 50 mm/s be used for construction blasting (whether there are regulations and/or seismograph monitoring or not).

With the prerequisite information above, Table 10 provides the converted values of PPV assigned to various household activities, as well as damage thresholds. This information provides easily understood everyday activities that create vibration levels similar to those caused by blasting.

Vibration Level (mm/s)	Activity or Threshold	Source
0.25 - 0.75	Human response test - the range of "slightly perceptible."	(Zieglar, 2000)
0.8	Walking	
7.1	Jumping	(Dowding, 1985)
12.7	Slam Door	
22.4	Pound Nails	
50	Recommended "best practice" limit for construction blasting	(ISEE, 2011)
76	Daily environmental changes (temperature cycles)	(Dowding, 1985)
137	Threshold for possible minor damage to typical residential structures	(ISEE, 2011)
183	Threshold for possible major damage to typical residential structures	(ISEE, 2011)

Table 10: Summary of ground vibration criteria

A home owner will want assurance that there will be no damage to their property (Penttinen, 2005). However, it is important to realize that there are two types of damage. The first is the likelihood of damage as a direct result of vibration, compared to everyday activities described in Table 10. The second is ensuring that "loose objects" are protected from falling as a result of vibration. Penttinen (2005) offers the following response to a concerned property owner:

"It is highly likely that in most blasting situations, intentional damage or cracking to structures will not take place if the blaster follows safe blasting practices. However, loose objects hung on, or leaning against walls or objects may fall or slip at very low levels of ground vibrations or airblast. It is imperative that . . . delicate objects that are
precariously mounted . . . be removed and stored temporarily during blasting operations" Penttinen (2005).

Thus, even quite low vibration levels can cause loose objects to fall.

### 5.3.2.3 Overpressure

Airblast, like vibrations, is another adverse environmental effect of urban blasting (Atlas Powder Co., 1987). Audible air blast is called "noise" and is measured and recorded with a microphone in terms of "overpressure." Blasting air overpressure is expressed as a sound equivalent in decibels on a linear scale dB(L) (ISEE, 2011).

In a similar manner to the vibration criteria, it is necessary to provide the people with the jurisdiction's acceptable limit, and the point at which damage may occur. It is then imperative to compare these values to daily environmental noises or pressures which people are much more familiar with.

In the province of British Columbia, there is currently no municipal or provincial blasting regulation that provides a limit on the decibel level of overpressure. However, this criterion may be included under a simple noise bylaw, if at all, which many municipalities do enforce. As shown in Figure 5, the US Bureau of Mines recommends a safe limit of 128 dB(L) for air overpressure at the closest structure to a blast (Atlas Powder Co., 1987).

It essential to explain the importance of exposure time to people, prior to comparing the decibel levels of typical blasting practice to common events. For example, the intensity of the audible portions of blasting typically span that of pneumatic chippers to jets taking off at a distance of 100 m away (Dowding, 1985). At first read, this may seem absolutely unacceptable to the concerned neighbour, however the peak air blast sounds last only a fraction of a second and is not repeated, as opposed to the continuous nature of a pneumatic chipper.

That being said, Table 11 compares the decibel levels of blasting practices, to the US Occupational Safety and Health Administration (OSHA) limits, as well as the converted pressures to other familiar occurrences. The noise limit is set 12 dB(L) under the threshold of pain for an impulsive sound. The converted pressure of those airblasts, are equivalent to wind gusts of 32 to 46 km/h. In Kelowna, BC, between 1971 and 2000, wind gust speeds have had a monthly maximum that range from 67 to 100 km/h (Environment Canada, 2011).

Noise Level dB(L)	Regulation (Atlast Powder Co., 1987)	Converted Pressure (Pa)	Wind Speed Equivalence (km/hr)
90	OSHA maximum for 8 hours of continuous exposure	0.6	3.5
115	OSHA – Complaints likely for 15 minutes of continuous exposure	11.2	15
120	Pain threshold for continuous exposure	20.0	20
128	Recommended limit for the impulsive sound produced by blasting (OSHA)	50.2	32
134	Recommended safe limit for impulsive sound by the US Bureau of Mines	100	46
140	OSHA absolute maximum for impulsive sound (threshold of pain)	200	64
150	Some windows break	633	115
170	Most windows break	6,325	362
180	Structural damage	20,000	644

### Table 11: Summary of overpressure criteria

### 5.3.2.4 Seismometers

Although every blaster would check with a neighbour before placing a seismometer on their property, it is important to also inform them of why it is there, and what it does. A seismometer is used to monitor ground vibrations and air overpressure (ISEE, 2011). The device is automatically activated, or triggered, by a vibration "event" and a seismograph is stored digitally and is then downloaded to a computer at the end of the day. The seismograph can include many parameters, depending on the model and programming options, however those of importance include the PPV of each vibration "event," as well as the corresponding peak air overpressure.

A typical seismometer is displayed in Figure 12. Seismometers come in all different shapes and sizes, however all seismometers should have a geophone, which measures ground vibrations in terms of PPV (mm/s) and a microphone which measures noise (dB(L)). Geophones are generally placed at the closest part of the closest structure to the blast. This is likely where vibrations will be the highest (ISEE, 2011), however geophones can be placed at any point of interest where vibration may be of concern. The geophone should be buried level underground with adequate backfilling and the arrow (seen in Figure 12) pointing directly at the blast. The microphone is placed on a stand, and similarly aimed directly at the blast.



Figure 12: Standard seismometer: Instantel Minimate Pro 6 (www.instantel.com/products)

It is proposed that by providing the homeowner with the installation guidelines of a seismometer will:

- Provide a simple explanation for the necessity of having the equipment on their property
- Ensure blasters are not taking advantage of uninformed homeowners by improperly installing the seismometer, and resulting in less-than-true maximum vibration and overpressure values.

## 5.3.2.5 Flyrock

Flyrock is a result of design faults, deviations in blast implementation, or unforeseen geological conditions (ISEE, 2011). However, an experienced driller, accurate drill logs, and inspection of

free faces can assist in identifying weak geological weaknesses. Thus, flyrock is essentially a product of poor blasting practice. WorkSafeBC reserves the right to suspend a blaster's certificate if flyrock is discharged off site, as it is a violation of the blasting regulations (J. Launay of Work Safe BC, pers. comm., Nov. 22, 2010). Enforced by WorkSafeBC, a construction incident or accident involving flyrock is a violation of Section 21.66 (1) of the provincial OHS Act, which states:

"The blaster must take precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material" (Work Safe BC, 2010).

This regulation, which would be provided to the affected property owners, would then be followed WorkSafeBC contact information who would investigate the incident. In British Columbia:

WorkSafe BC Claims call center Toll Free: 1-888-967-5377

As previously discussed, it is proposed that by providing this contact information to the neighbours, it will:

- Increase the integrity and validity of the information provided to them
- Provide the public with a complaint mechanism (for flyrock only)
- Increases blaster accountability to ensure safe practices are being followed

In addition, assuming that the communication is done door-to-door, the blaster (or a representative on their behalf) will gain knowledge of the proximity of the properties to the blast site.

### 5.3.2.6 Permits and regulatory oversight

It is essential that information provided to the affected people corresponds directly to the regulations within the jurisdiction of the blast site. For example, if there are no limits on PPV, or overpressure, or regulations that require a blasting permit or monitoring of every blast, confusion will arise if people receive detailed blasting information for which no regulations exist. Thus a

communication bridge must be coupled directly with appropriate regulations. A suggested regulatory framework for municipalities to adopt is presented later.

## 5.3.2.7 Blaster qualifications

In addition to necessary permits, the affected people must also be ensured that the blaster conducting the work in close proximity to their home is a competent individual with experience in urban blasting, and holds a valid blaster's certificate (Penttinen, 2005). In British Columbia, as stated in section 21 of the OHS Act, a blaster must have a valid blasting certificate issued by or accepted by Work Safe BC (Work Safe BC, 2010a). It is stated:

"In BC, only the holder of a valid Blaster's Certificate issued by WorkSafeBC, or acceptable to WorkSafeBC, is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate" (Work Safe BC, 2010b).

In addition, in British Columbia, the blaster must also obtain the urban blasting designation, which is located on the license, in order to carry out close-in blasting.

### 5.3.2.8 Approach with blasting near structures

All of the special precautions that a blaster may take to reduce the magnitudes of vibration and overpressure, as well as the chances of flyrock must be stressed (Penttinen, 2005) including:

- Use of blasting mats
- Limiting blast size and weight of explosive per delay
- Use of special time delays
- Strategic orientation of the blast

These specific precautions may be expressed to the neighbour, in layman's terms, with discretion. Again, it is important to couple this information (specifically blasting mats) with the jurisdictional regulations. If a municipality were to enforce that blasting mats be used to protect neighbours from flyrock, it would be highly advantageous to describe what the blasting mats are, and what they are used for.

## 5.3.2.9 Site geology and response of structures

Regardless of the amount and detail of education which is relayed to the affected people, Penttinen (2005) found that one particular misconception is always a point of interest: "Often persons feel that the site geology under their home is unique to the site and want to be assured that the blaster will consider this uniqueness. In addition, many persons feel that their home is also unique in construction or foundation design. 'Uniqueness' may need to be addressed by explaining that most structures respond similarly within a very narrow range of response characteristics and that safe blasting guidelines and regulations account for this uniqueness" (Penttinen, 2005).

#### 5.3.2.10 Pre-blast surveys

A pre-blast survey is used to establish a record of the pre-existing condition of a structure (ISEE, 2011). A secondary use of pre-blast surveys is to establish a positive line of communication between the site and the nearby property owners, as well as educate the neighbour on safe blasting practices (ISEE, 2011), (Murray and Bender, 1988), (Ziegler, 1997), and (Penttinen, 2005).

This "getting your foot in the door" approach is an excellent way to educate people and discuss their potential concerns (Penttinen, 2005). The intention of this section of the report is to describe in "layman's terms" what a pre-blast survey is, and how it will be conducted.

Property owners must be assured that the general reason for conducting a pre-blast survey is not because damage is likely, but because claims of damage are common (Ziegler, 1997). However, this objective gives a sense of one-sidedness or may suggest that the pre-blast survey is to gather evidence to solely aid in claims against the blaster, and this is certainly not the case. The ISEE (2011) provides an example of a pre-blast survey notification letter which was distributed to all residences within a half-mile of a mine site in the US. In this document the purpose of the pre-blast survey is to:

- 1. Establish a pre-blasting record as to the existing condition of the structures on a given property,
- 2. Identify structures or contents that may be sensitive to vibrations, and
- 3. Initiate communications about blasting between the blaster and nearby homeowners.

The inclusion of points 2 and 3 are highly attractive to the homeowners who may seek assurance on the safety of their home, their belongings, as well as answers to any questions regarding blasting practices which they may have.

Pre-blast surveys are not a requirement of blasting regulations in British Columbia. However, they should be used because they hold three strong complaint reduction mechanisms:

- 1. Initiate communication and education to the homeowner (Penttinen, 2005).
- 2. The inspections may reduce, but not eliminate, complaints of structure response to vibration and airblast since the owner is now aware that the true pre-existing condition of their home is documented (Ziegler, 1997).
- 3. If the pre-blast survey was thoroughly conducted, when a damage claim is made, the fault of the blaster, or the pre-existence of the defect is quickly clarified (ISEE, 2011).

### 5.3.3 Effective knowledge transfer

The means in which blasting-related information is relayed to the homeowners is dependent on the jurisdictional regulations, as well as the parties involved. For example, if a blasting contractor was working in a densely populated city environment, they may hire a third-party blast consultant to conduct all blast monitoring pre-blast surveys. Moreover, if blasting was to occur for a new subdivision, and there were only 3 properties within close proximity of the blast, the blaster may deem it necessary to take on that role themselves, if at all. Regulations play a major factor as well. If pre-blast surveys are not a requirement of the project, or included in local regulations, the possibility of a blasting contractor spending thousands of dollars on pre-blast surveys is virtually eliminated.

A literature review of attempted knowledge transfer mechanisms was conducted and the results are shown in Table 12.

It is proposed that regulations forcing blasters to deliver a pamphlet would be the least objectionable of all the options provided in trial conducted by Sanders and Luchansky (1993) resulted in the highest complaint reduction percentage of 90%. With education of blasting practices as the number one priority for complaint abatement, complaints were drastically reduced by distributing flyers a week prior to blasting and by inviting neighbours to an optional pre-blast meeting where an instructional video and a question and answer session commenced (Sanders and Luchansky, 1993). The only information which was provided to 100% of the neighbours within a close proximity of the blast site was the instructional flyer:

"A distinctive bi-fold flyer was developed for distribution to nearby residences and businesses. The flyer has cut-out for attachment to doors and it is printed in bright 'neon-glow' colours. A Las Vegas seal is on the face of the flyer; the contents reflect basic considerations concerning safety and the elimination of damage potential" (Sanders and Luchansky, 1993).

An informative flyer / pamphlet is suggested as the most practical means of knowledge transfer for the following reasons:

- The information delivered to the neighbour is consistent
- Requires minimum personnel and man-hours (compared to the other suggested methods) to convey the information. This is typically already required in those municipalities that have blasting bylaws in BC.
- It is proposed that regulations forcing blasters to deliver a pamphlet would be the least objectionable of all the options provided in Table 12.

The proposed pamphlet is included in Appendix C.

	Murray and Bender (1988)	Ziegler (1997)	Pentinnen (2005)	Fritzen (2000)	Lucca (2004)	Shukla (1978)	Sanders and Luchansky (1993)
Pre-blast survey	Х	Х	Х	Х			
Door-to- door PR				Х			
Call lists					Х		
Consultant retention					Х		Х
Pre-blast meetings						Х	Х
Video							Х
Flyer							Х

 Table 12: Recommended complaint abatement procedures

# 5.4 Bylaw Development

In order for the education plan to be effective, the proposed pamphlet must be complemented by a bylaw that contains municipal regulations consistent with the pamphlet. The regulations must have the following characteristics:

- 1. Minimize complaints of vibration, and overpressure made by affected homeowners
- 2. Minimize the risk to the municipality

- 3. Minimize the time commitment by the city engineer or inspector and costs to the city
- 4. Have a minimal effect on contractor productivity

### 5.4.1 Methodology

Using the first three criteria, the effectiveness of current bylaws was analyzed and proposed regulations were developed. Six municipalities from Table 2 were chosen and organized in the following categories:

- **Heavily regulated** (*West Vancouver and Sechelt*) Bylaw requires blaster to monitor every blast, conduct pre-blast surveys, notify affected homeowners of blasting and the owner must retain a blast consultant to supervise all blasting operations / ensure compliance with bylaw.
- **Moderately regulated** (*Colwood and Highlands*) Specifications within the bylaw vary including: pre-blast surveys, monitoring blasts, notification to neighbours however blast consultants are not used. The municipalities maintain a 'self-regulating' approach and reserve the right to request seismographs, or pre-blast surveys at any time. If the blaster cannot immediately provide the information, their permit is revoked.
- Not regulated (Nanaimo and Kelowna) No bylaws are present

Interviews were conducted with the city engineers and inspectors at the municipalities. For West Vancouver, Sechelt, Colwood and Highlands, the bylaws were inspected and analyzed in terms of complaints, risk, and time commitment. In addition, advantages and downfalls of each municipality's bylaw, as well as proposed amendments were discussed. For Nanaimo and Kelowna, those municipalities without a blasting bylaw but have shown interest in adopting one, interviews were used to tabulate desirable characteristics in a harmonized bylaw.

Using the proven effective clauses from the various municipalities' bylaws, and the expectations of Kelowna and Nanaimo, a proposed blasting bylaw was developed.

The literature review and proposed guidelines were then presented at the International Society of Explosives Engineers (ISEE) Annual General Meeting (AGM) for the Western Canada Chapter. This annual event attracts a majority of the blasting contractors, consultants and government authorities whose jurisdiction falls within the blasting industry. After presentation of the proposed bylaw, a one-hour discussion between all attendees was conducted to solicit opinions

on the draft proposed regulations. The objective of this discussion was to ensure that the bylaw was practical for implementation and would have a minimal effect on contractor productivity.

Finally the proposed bylaw was refined by taking into consideration the feedback obtained by the attendees of the ISEE's annual general meeting.

### 5.4.2 Heavily regulated municipalities

### 5.4.2.1 Summary of bylaws

West Vancouver and Sechelt have the most prescriptive blasting bylaws in British Columbia. Sechelt's bylaw is essentially a copy of West Vancouver's bylaw and was adopted in the middle of a major incident at the Trail Bay Estates development. Both municipalities require the owner, at the owner's expense, to retain a professional engineer, with a proven record of blasting experience, to supervise blasting activity and ensure full compliance with the bylaw. Some of these assurances include the items listed below (District of West Vancouver, 1996):

- A permit must be provided to the city including;
  - a copy of a valid blasting certificate
  - Certificate of insurance (minimum liability insurance of \$5,000,000)
  - Blast Plan including the blast pattern, delay sequence, and maximum weight of explosives per delay.
  - Control Measures Plan including a detailed account of the measures designed to minimize the impacts of blasting. If blasting is not within 150 m of a structure, utility line, railway, public or private road, street, lane, driveway or walkway or is not expected to produce a rock cut of over 3.5 m then the engineer may waive the requirement to produce a Control Measures Plan.
  - A report on the results of a pre-blast survey made of all principal structures at a distance specified by the engineer
- Ground vibration measurements shall be made at the closest structure to the blast and the Engineer shall be present at the first blast that is of the full magnitude specified in the control Measures / Blasting plan. Throughout blasting, the blaster must forward the measurements to the engineer and in no circumstance shall ground vibrations at any structure exceed a PPV of 50 mm/s.

- The blaster must give at least one week's notice of any blasting expected to continue for more than two days to all "affected owners" (the same radius specified by the engineer where pre-blast surveys are conducted).
- An "affected owner" has 60 days to report a claim to the blaster.
- All or some of these provisions *may* be exempt if:
  - Less than 10 m<sup>3</sup> of rock is to be blasted by means of detonating not more than 0.3 kg/delay
  - The rock to be blasted consists entirely of boulders separate from bedrock

In the District of Sechelt, all of the above provisions are included in the bylaw in addition to the following (District of Sechelt, 2007):

- Blast hole size is restricted to 70 mm diameter
- The blasting permit must be renewed every two weeks
- Pre-blast surveys are conducted at a distance of 150 m from the blast site.
- The bylaw specifies that a blasting "specialist" (not an engineer) must be retained
- Require the use of blasting mats for every blast

### 5.4.2.2 Interviews

On July 28<sup>th</sup> 2011, interviews were carried out with municipal engineers for the District of West Vancouver and the District of Sechelt to discuss the effectiveness of their bylaws. Table 13 compares and contrasts the municipalities' blasting bylaws including: complaints of vibration and overpressure, risks to the municipalities, and time and financial commitment to regulating blasting. Recall that in both municipalities, the bylaws are fundamentally the same.

### 5.4.2.3 Analysis

**Complaints** - In both Districts, since the complete implementation of their respective bylaws, there have been very few complaints of vibration and overpressure. The prescriptive provisions included in the municipalities' bylaws are effectively reducing the number of complaints (proven by the reduction in complaints before and after the implementation of the bylaw in Sechelt as shown in Table 8.

	District of West Vancouver	District of Sechelt
Source	(T. Tse, pers. comm., July 28 <sup>th</sup> 2011)	(K. Tang, pers. comm., July 28 <sup>th</sup> 2011)
Why was the bylaw implemented?	(1996) <i>Proactive</i> : "Definitely not a reaction to a major incident."	(2007) <i>Reactive</i> : "After numerous complaints at a development project, the District of Sechelt adopted West Vancouver's bylaw (mid-project at the Trail Bay Estates Development)."
How many blasting permits are authorized per year?	<i>30 to 40 permits per year</i> almost entirely residential	<i>3 to 4 permits per year</i> , but long term projects and permit must be renewed every two weeks.
What is the time commitment by the District?	2-3 hours / week (~1.5 hours / permit)	During the Trail Bay Estates incidents roughly 6 h /week. Once that subsided, (2008 to present) roughly 1 hour per week (~ 16 hours / permit)
On-site commitment by someone from the District	"None: there are no bylaw officers; enforcement is left to the engineer. The insurance company also ensures self-governance."	"None: all control is relied on the expertise of the blasting engineer."
Complaints	< <i>1 damage complaint / year</i> ("They are very minor such as a plate falling to the kitchen floor")	< 1 complaint per year and no damage claims ("we haven't had too many neighbour complaints since 2007")
Nature of the complaints	Noise ( <i>overpressure</i> )	Vibration and overpressure
Nature of the complaints Risk	Noise ( <i>overpressure</i> ) "We will always have risk, because the lawyer will always go after the people with big bucks. I think the first person that would get hit is the blaster then the engineer and the District will also be sued."	<i>Vibration and overpressure</i> "If the bylaw requirements are adhered to and the engineer is fulfilling its responsibility, I think that the District is exposed to very minimal risk. But of course we are not there; we do not stand on site."
Nature of the complaints Risk Amendments the municipality is currently considering	Noise ( <i>overpressure</i> ) "We will always have risk, because the lawyer will always go after the people with big bucks. I think the first person that would get hit is the blaster then the engineer and the District will also be sued." "None related to blasting (considering reducing the permitted rock volume removal from 600 m <sup>3</sup> to 200 m <sup>3</sup> )."	Vibration and overpressure "If the bylaw requirements are adhered to and the engineer is fulfilling its responsibility, I think that the District is exposed to very minimal risk. But of course we are not there; we do not stand on site." "(i) Ensuring that the consultant is a professional engineer rather than a "specialist" (with no formal credentials) and (ii) implementing a bond as an assurance that PPV levels will remain under 50 mm/s."
Nature of the complaints Risk Amendments the municipality is currently considering Lawsuits or settlements	Noise ( <i>overpressure</i> ) "We will always have risk, because the lawyer will always go after the people with big bucks. I think the first person that would get hit is the blaster then the engineer and the District will also be sued." "None related to blasting (considering reducing the permitted rock volume removal from 600 m <sup>3</sup> to 200 m <sup>3</sup> )." "One settlement between the contractor and owner. There was a claim and the blaster paid it. Blaster's deductible was \$10,000"	<ul> <li>Vibration and overpressure</li> <li>"If the bylaw requirements are adhered to and the engineer is fulfilling its responsibility, I think that the District is exposed to very minimal risk. But of course we are not there; we do not stand on site."</li> <li>"(i) Ensuring that the consultant is a professional engineer rather than a "specialist" (with no formal credentials) and (ii) implementing a bond as an assurance that PPV levels will remain under 50 mm/s."</li> <li>"The district is currently involved in a lawsuit from the incident at Trail Bay Estates in 2007".</li> </ul>

## Table 13: Comparison of heavily regulated municipalities

**Risk** - The risk exposure to both municipalities is virtually the same. In both cases, the municipality is the third party in line to be sued (Blaster  $\rightarrow$  Engineer (or Specialist)  $\rightarrow$  District). However, it is assumed that the financial risk to West Vancouver is smaller because the

consultant must be a professional engineer with credentials, and likely carries much higher liability coverage. The proposed amendment by the District to ensure that the consultant is a professional engineer rather than a "specialist" would be highly advantageous. The District of Sechelt also reiterates the WorkSafeBC requirement that blasting mats or other cover must be used to prevent flying material. The inclusion of this clause, which is already regulated by WorkSafeBC, adds additional risk to the municipality if blasting mats are not used by the contractor. It is recommended that the District of Sechelt removes the provisions that attempt to regulate flyrock and leave it to the provincial government.

**Time Commitment** - It is difficult to compare the time commitments made by each of District's staff since the permit lengths vary within and between municipalities. However, since both municipalities have reported very few complaints, it is assumed that nearly all of their time reported is spent administering permits and consultation with the consultant. As shown in Table 13, the engineer's time commitment in West Vancouver and Sechelt is 1.5 hours and 16 hours per permit respectively. Since both municipalities have minimized the number of complaints, it is clear that the permit renewal process, every two weeks, in the District of Sechelt is unnecessary and extremely time consuming.

Advantages of Bylaw - The advantages of the highly prescriptive bylaws are significant reductions in complaints made by affected homeowners. Although the administrative process behind blasting is exhaustive, there are very few complaints and little to no claims have been made.

**Downfalls of Bylaw** - As noted in Table 13, the District of Sechelt has received many complaints from contractors, consultants and owners that the bylaw is too restrictive and costs them a lot of money. For example, if blasting was to occur in a densely populated area of Sechelt, and the pre-blast survey radius is 150 m, the survey could be extremely costly. It is recommended that the pre-blast survey radius or "affected owners" should be determined by an experienced blasting consultant. Apart from the blast-hole size restriction in the District of Sechelt, all other provisions of their bylaw that differ from West Vancouver's bylaw seem to cause problems. It is recommended that they should be changed back to the original West Vancouver document. However, in both municipalities, there is no limit on overpressure. It is

recommended that a limit of 128 dB(L) be used for the closest structure to the blast (Atlas Powder Co., 1987).

### 5.4.3 Moderately regulated municipalities

### 5.4.3.1 Summary of bylaws

The District of Colwood and the City of Highlands are moderately regulated municipalities because they have bylaws that regulate blasting within their respective jurisdiction. However, the provisions are less prescriptive than West Vancouver and Sechelt, and there is little to no enforcement program. The following is a brief comparison of the two bylaws.

In the City of Colwood, the blaster is essentially self-regulated as there is no formal enforcement program, other than the City reserving the right to request information, such as seismograph records at any time. A blaster proposing to blast in Colwood must meet the following requirements (City of Colwood, 1994):

- Apply for a permit which is approved after receiving:
  - The location of where blasting is to be conducted, as well as blaster contact information
  - A checklist of measures taken to reduce the risk of flyrock (blasting mats, sand or clean fill)
  - Proof of insurance (at least \$5,000,000 liability coverage)
  - A draft letter of notification of blasting to be handed out to neighbours, at least 48 hours prior to the commencement of blasting, within 300 m of the edge of the blast.
  - Pre-blast survey report if any bridge, dam, building or any other structure is within 60 m of the blast site. The survey must be conducted by an independent insurance adjuster.
- Monitor the blast with at least one seismometer at the nearest structure to the blast and the vibration records be kept and available to citizens and the City upon request.
- Provide a final report to the city including vibration records, blasting logs, and all records pertaining to the safety aspects of the project.

In the District of Highlands, the blaster is similarly self-regulated. A blaster proposing to blast in Highlands must meet the following requirements (District of Highlands, 1996):

- Apply for a permit which is approved after receiving:
  - The location of where blasting is to be conducted, as well as blaster contact information
  - Site plan due to "a lot of water in the highlands, sensitive forests etc." (C. Leek, pers. comm., July 27<sup>th</sup> 2011). Mr. Leek then visits the site to inspect the location of blasting.
  - A checklist of measures taken to reduce the risk of flyrock (blasting mats, sand or clean fill)
  - Proof of insurance (at least \$2,000,000 liability coverage)
  - A brief description of the method of notification of blasting, which is to be conducted 100 m from the edge of the blast (with no specific time constraint).
- Monitor the blast with at least one seismometer for all major blasts (that move 10 m<sup>3</sup> or more of rock), at the nearest structure to the blast and the records be kept and available to citizens and the District upon request. Blasts that are smaller than 10 m<sup>3</sup> (minor blasts) are not required to be monitored.
- Provide a blasting log for all major blasts.

### 5.4.3.2 Interviews

On July 26th and 27<sup>th</sup> 2011, interviews were conducted with the municipal engineer and building inspector for the City of Colwood and the District of Highlands respectively. Table 14 compares and contrasts the effectiveness of the bylaws including, but not limited to complaints of vibration and overpressure, risks to the municipalities, and time and financial commitment to regulating blasting. Recall that in both municipalities, the bylaws have a similar 'self-regulating' procedure with no formal enforcement process.

### 5.4.3.3 Analysis

The fundamental differences between the bylaws are that Colwood requires pre-blast surveys for structures within 60 m of the blast site, and notification to neighbours must be made to all homes and businesses within 300 m of the blast, 48 hours prior to the blast. In Highlands, the

notification radius is only 100 m, there is no specified minimum time that the blaster has to inform the affected homeowners, and pre-blast surveys are not required.

**Complaints** - In both municipalities, there is approximately one to two blasting permits approved each month. According to the City building inspector for the District of Highlands, every time there is a blast, there are telephone inquiries/complaints made to the city (one call for every permit). In the city of Colwood, on the other hand, there is only one telephone inquiry or complaint made to the city for every three months (one call for every 3 to 6 blast permits). As previously discussed, questions and concerns regarding blasting can be easily addressed during pre-blast surveys. This, in addition to a larger notification radius (300 m rather than 100 m) may be the contributing factor for the reduced number of complaints in the City of Colwood, since the remainder of the bylaws between the two municipalities are virtually the same. It is recommended that the District of Highlands increases the notification radius to 300 m, and requires the blaster to ensure pre-blast surveys are completed.

**Risk** – The risk to the District of Highlands is higher than the risk to the City of Colwood. Preblast surveys are often used to settle damage claims, whether legitimate or frivolous, by quickly establishing if the damage is pre-existing or not. Since the District of Highlands does not require pre-blast surveys to be conducted, they are exposed to more risk as the probability of a claim settling between the blaster and affected homeowners before trial is lower. However, both municipalities are exposed to a great deal of risk if an incident were to occur, because there is no reasonable attempt to ensure compliance with the bylaw. Of course it would be the blaster who is primarily responsible for a serious incident or damage, but both the Districts of Highlands and the City of Colwood would be at fault for failure to enforce the bylaw.

**Time Commitment** – The moderately regulated municipalities, with bylaws that are less prescriptive than in West Vancouver and Sechelt, require significantly less time commitment from the municipal authorities. In both Highlands and Colwood, each permit only requires approximately one hour of the engineer's or building inspector's time, totalling approximately one to two hours per month.

	District of Highlands	City of Colwood
Source	(C. Leeks, pers. comm., July 27 <sup>th</sup> 2011)	(H. Lockhart, pers. comm., July 26 <sup>th</sup> 2011)
Why was the bylaw implemented?	1996: N/A	1993: N/A
How many blasting permits per year?	Varies: in 2010 there were 18 permits (~1-2 permits / month)	~1 – 2 permits / month
What is the time	~ 0.5- 1 hour / permit	~ 1 hour / permit
commitment by the District?	(~1-2 hours / month)	(~1-2 hours / month
On-site commitment by someone from the District	One site visit per permit is conducted by the City inspector. "I go out and visit the site and they indicate where blasting will occur"	None
Complaints	"Every time we blast we get a phone call." (~1-2 calls / month)	"Over the past three years there has been an average of one call every three months" (~ 1 call / 3 months)
Nature of the complaints	Vibration and Overpressure	Vibration and Overpressure
Risk	" we issue the permit; we are responsible for what is in the bylaw. They will name everybody; they will name the district, the blaster, they would name the contractor".	"The bylaw is mainly in place to ensure that the blaster is taking the necessary precautions and that the city knows about it".
Lawsuits or settlements	None	None
Amendments the municipality is currently considering	None	None
Opposition from contractors	N/A	N/A

### Table 14: Comparison of moderately regulated municipalities

Advantages of bylaw - Blasting is moderately regulated within these municipalities and requires very little administrative time.

**Downfalls of bylaw** - The downfall of both the City of Colwood and the District of Highlands' bylaws is the lack of formal enforcement. Both municipalities use a trust-based system where they reserve the right, at any time, to ask for seismograph records for any particular blast. If the blaster is unable to produce this data, then their blasting permit can be revoked by the

municipality. In addition, there are no specified PPV limits. The bylaws state that the blast must be monitored with a seismometer; however there are no specific limits on vibration or overpressure. The municipalities are exposed to more risk than West Vancouver and Sechelt, and the bylaws are less effective. In the District of Highlands, complaints occur every time a blast goes off. This suggests that the blasters are not effectively notifying the public prior to blasting.

### 5.4.4 Municipalities that are not regulated

In BC, 134 of the 157 municipalities, accounting for 70% of the provincial population, have no blasting regulations at the municipal level. In these municipalities, there are no regulations requiring blasting monitoring for vibration and overpressure, pre-blast surveys or notification to surrounding neighbours. Reports in local newspapers provide insight into complaints triggered by urban blasting.

## 5.4.4.1 Selection of municipalities

The cities of Nanaimo and Kelowna were non-regulated municipalities selected for interviews. In Nanaimo, Toby Gorman writes:

"... 'When it goes, everything in the house rattles, and I'm concerned repeated blasting is making the rock shelf above the backyard unstable.' Despite the close proximity, Herchak's home hasn't been damaged and she understands the developer's right to build. She just wants a little security should something happen. Currently, blasting is not regulated by most municipalities nor the province, but Nanaimo city council is taking a look to see if it should step in to oversee the practise" (Gorman, 2010).

The news reports documented complaints of flyrock, vibration, and overpressure as well as the municipalities' concerns with regulating the issue. The City of Kelowna documented the same concerns:

"... while the city is not taking on responsibility for blasting, it is taking on a mediation role. 'In this particular case, we're making it quite clear. We're not assuming any liability. All we will do is try to bring the parties together so someone has someone they can [ask] questions to'" (Nieoczym, 2010).

### 5.4.4.2 Interviews

On June 22<sup>nd</sup> and July 27<sup>th</sup> 2011, interviews were conducted with the municipal engineers for the Cities of Kelowna and Nanaimo respectively. Table 15 compares and contrasts the information obtained from these interviews.

# Table 15: Comparison of the interviewed municipalities that are not regulated

	City of Nanaimo	City of Kelowna
Source	(D. Mousseau, pers. comm., July 27 <sup>th</sup> 2011)	(S. Muenz, pers. comm., June 22 <sup>nd</sup> 2011)
What is the current status of implementing a blasting bylaw?	"We are trying to implement guidelines that are not enforced, but recommended – to try to get to the point where we are reasonably looking after the residents, but also leaving all of the liability to the blaster. It's performance-based, rather than specifying a specific PPV limit, we want to put the onus back on the blaster to ensure safety of the public".	"Staff doesn't think we need a blasting bylaw, but at the same time we make ourselves available to facilitate meetings between parties, and that's what I've been doing".
Most common Complaints?	Vibration and Overpressure	Vibration and Overpressure
What is the hesitation in implementing a blasting bylaw?	"The liability and cost/exposure to the city, as well as the cost of enforcement to the city. We come from a civil background, and we would have to hire a bylaw officer specifically for blasting who would need to be trained etc. Or have a consultant on retainer. But we have two- three blasts a year so it is just not worth it".	"We just don't want to take on the responsibility, it becomes a liability, we become a third party and then if anyone gets sued, we get involved with it, we're going to get sued toothat's the main reason and we just feel that we don't have the expertise to issue something".
What is the best course of action?	"Most of the flat development is done and blasting along the hill-slopes will increase greatly in the future and this is why we are moving along with this [implementing a bylaw or set of guidelines]".	"From the city's point of view? We will maintain the status quo".
What is the current risk to the city if there were a major incident?	None	None
What are the proposed bylaw characteristics?	"We are seeking compliance [to industry standards] to eliminate concerns. We would be looking for something that is more performance- based rather than hard criteria. The problem with hard-criteria is that you have to cover every single circumstance that you may run into. You have seen some instances where PPV of 50 mm/s is fine, but there may be areas where you need to be tighter than that (very old heritage homes in Nanaimo). We want some guidelines and principles. I think it is very important to rank your hazard or risk as low-medium-and high and for each, have different criteria that you must adhere to. We have also been looking into the blasting company to provide us with a bond".	None

	City of Nanaimo	City of Kelowna
Why not download the risk to an engineer that supervises the work (City of West Van / Sechelt)	No Response	"Ultimately yes, but even if there is an engineering problem and there is an engineer on record we would still get sued, and a lot of times if the engineer on record doesn't have enough money, then they go to the city assuming we have deeper pockets."

## 5.4.4.3 Analysis

In the City of Kelowna, it is clearly the opinion of the engineering staff that the city does not want to implement a blasting bylaw. It is felt that the assumed risks, costs and time required to regulate the issue are not necessary. Although many complaints are made to the city, there is no formal processing and very little data is available on the number of complaints or the amount of blasting that is conducted within the municipality per year. Maintaining the status quo, while bringing the concerned neighbours, blasters, developers etc. together is the proposed resolution mechanism by the City.

The City of Nanaimo, on the other hand, proposes a performance-based system that is quite similar to the bylaws that have been implemented in the City of Colwood and District of Highlands. In a report submitted to council by Dean Mousseau, there were three options, with respect to dealing with blasting issues, that were considered;

"Option 1 – Continue with the current practice of addressing concerns on a case-by-case basis and pursue voluntary compliance that blasting contractors meet accepted industry standards.

**Option 2** – Develop guidelines and an education program to require that all blasters raise the level of care and attention they employ when conducting blasting activity within the City.

**Option 3** – Develop a comprehensive bylaw to regulate blasting activity. This option would expose the City to increased liability, increased construction costs for developers and home builders, and requires specialized expertise that the City currently does not possess" (D. Mousseau, pers. comm., July  $27^{\text{th}} 2011$ ).

Mr. Mousseau continued to explain that Option 2 was the selected course of action by the City of Nanaimo, but that the guidelines had yet to be developed. The enforcement procedures would be similar to the City of Colwood and District of Highlands:

"We aren't going to say that the blaster is required to do it, but if we ask for it – we better have your seismograph records and then we would make that available to the neighbours" (D. Mousseau, pers. comm., July  $27^{\text{th}}$  2011).

Both Nanaimo and Kelowna are mainly concerned with the risk that the cities would assume if they were to implement anything too prescriptive. However, this will not reduce the number of complaints or calls to the city, and it is recommended that both municipalities adopt some form of bylaw.

## 5.4.5 Comparative-analysis of all interviewed municipalities

The final step in the analysis of municipal bylaws was to perform a comparison, as shown in Table 16, of the three categories of regulations:

- 1. Heavily Regulated West Vancouver and Sechelt
- 2. Moderately Regulated Colwood and Highlands
- 3. Not Regulated Kelowna and Nanaimo

Table 16 shows that if a bylaw were to be put in place, and as the bylaw becomes more prescriptive, there is less risk to the municipality. In the analysis between Sechelt and West Vancouver the specification that the consultant must be a professional engineer rather than a specialist is found to reduce the risk further to West Vancouver. When the data is normalized to time commitment per permit, the time required by the West Vancouver City Engineer is not significantly greater than the engineer and inspector in the Districts of Colwood and Highlands respectively. Most importantly, complaints are also reduced to less than one per year.

Without taking into account the affect that these bylaws have on blasting productivity, it is therefore suggested that the West Vancouver bylaw is the most appropriate draft that maximizes the criteria of reducing:

- i. complaints of vibration, and overpressure made by affected homeowners,
- ii. risk to the municipality,
- iii. time commitment by the city engineer or inspector and costs to the municipality.

Therefore, it is proposed to blasters and consultants that the bylaw contains at least the following clauses, as regulated in West Vancouver:

• Permit including:

- a copy of a valid blasting certificate
- Certificate of insurance (minimum liability insurance of \$5,000,000)
- o Blast Plan including the blast pattern, delay sequence, and maximum weight/delay
- Control Measures plan including a detailed account of the measures designed to minimize the impacts of blasting. If blasting is not within 150 m of a structure, utility line, railway, public or private road, street, lane, driveway or walkway or is not expected to produce a rock cut of over 3.5 m then the engineer may waive the requirement to produce a control measures plan
- A report on the results of a pre-blast survey made of all principal structures at a distance specified by the professional engineer
- Ground vibration measurements shall be made at the closest structure to the blast and the Engineer shall be present at the first blast that is of the full magnitude specified in the Control Measures / Blasting plan. Throughout blasting, the blaster must forward the measurements to the engineer and in no circumstance shall ground vibrations at any structure exceed a PPV of 50 mm/s.
- Blaster must give at least one week's notice of any blasting expected to continue for more than two days to all "affected owners" (the same radius specified by the engineer where pre-blast surveys are conducted).
- An "affected owner" has 60 days to report a claim to the blaster.

### 5.4.6 Amendments by contractors and consultants

Using the recommended bylaw framework that is deduced from meetings with BC municipalities above, amendments are made by blasting contractors and consultants to ensure that the bylaw causes minimal disturbance to blasting productivity and avoids unnecessary costs.

### 5.4.6.1 Methodology

All preceding research and recommended clauses to be included in a harmonized bylaw were first presented on August 22<sup>nd</sup> to Rob Cyr, a blasting expert who has 20 years of international blast consulting experience. Similarly, this information was also presented at the Western Canada Chapter of the International Society of Explosives Engineers' (ISEE) Annual General Meeting (AGM) in Vernon, BC on October 16<sup>th</sup> 2011. This annual conference included 36

blasters, consultants, explosives providers, WorkSafeBC representatives, Ministry of Mines representatives and many other stakeholders of the industry. Recommendations were made by participating attendees and are summarized below. It is important to note that there is an equal bias from all parties that may be looking out for their best interest – minimizing costs and maximizing available work in their respective markets. The participants of this discussion include;

- Ron Elliott (Blasting Contractor) Pacific Blasting & Demolition Ltd.
- Jim Launay (Blasting Inspector) WorkSafeBC
- Anonymous (Blasting Inspector) BC Ministry of Mines
- Alastair Grogan (Blasting Consultant) Grogan Rock Consulting Ltd.
- Unanimous All conference participants agree

Municipality	Permit	Notificatio n	Monitoring	Pre-Blast Surveys	P.Eng / Specialist	Risk <sup>1</sup>	Time Commitment <sup>2</sup>	Complaints / Permit <sup>3</sup>
Kelowna	X	X	X	X	X	0 None	0 None	4 High (according to newspapers)
Nanaimo	X	Х	Х	Х	Х	0 None	0 None	4 High (according to newspapers)
Highlands	~	✓ (100 m)	✓ (No Limit)	Х	Х	4	1 ~ 0.5- 1 hour / permit (1-2 hours / month)	3 ~1-2 complaint / month (1 call / permit)
Colwood	~	✓ (300 m)	✓ (No Limit)	✓ (60 m)	Х	3	2 ~ 1 hour / permit (1-2 hours / month)	2 ~ 1 complaint / 3 months (1 call / 3 – 6 permits)
Sechelt	~	✓ (as per specialist)	✓ (50 mm/s)	✓ (150 m)	✓ (Specialist)	2	4 ~ 16 hours / permit (1 hour / week)	1 < 1 complaint / year (< 1 call / 3 to 4 permits)
West Van	~	✓ (as per P.Eng)	✓ (50 mm/s)	✓ (as per P.Eng)	✓ (P.Eng)	1	3 ~1.5 hours / permit (2-3 hours / week)	<b>0</b> < 1 complaint / year (< 1 call / 30 to 40 permits)

Table 16: Cross-analysis of all interviewed municipalities

(**Rankings:** 0 -Lowest, 4 -Highest) <sup>1</sup> Risk of the municipality being sued if there were an incident. <sup>2</sup> Time spent on the administration / enforcement of the bylaw by the municipal engineers / inspectors. <sup>3</sup> Phone calls / claims / inquiries made to the municipality.

## 5.4.6.2 Permit

Rob Cyr begins by explaining that, in his experience, municipalities are moving away from the permitting process due to the liability it imposes, and suggests that the requirements prior to approving a blasting permit should be minimal:

"A lot of municipalities are moving away from the permitting process, because of the liability issue. The city of Ottawa has no permit anymore, and the legal basis for it is that if you issue a permit, you are, in a manner of speaking, approving what they are doing. But whether you issue a permit or not, you are opening yourself up to liability. If something happens, people are going to sue everybody anyway. OPS-120 does not require a permit; however Halifax does. The permit should require as little as possible documentation" (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

The recommended bylaw framework deduced from the analysis of municipal bylaws states that prior to being approved to blast, the blaster must obtain a permit by providing the various information shown below. The opinions expressed by attendees of the ISEE's AGM in Vernon, BC on each of these permit requirements is also provided:

- *Blaster Certificate* –must have urban blasting designation on the ticket (Unanimous)
- *Insurance* minimum \$5,000,000 liability insurance (Unanimous)
- Pre-Blast Survey Report / Control Measures and Blasting Plans If all of these regulations are written into the bylaw, it would be unnecessary to require a control measures / blast plan / pre-blast survey report submitted for every single blast. The blaster will simply change the title of the job / date each time they blast (Unanimous)

### 5.4.6.3 Retaining a professional engineer

There was no opposition by blasting contractors to require that a consultant be retained for all blasts. However, the proposed regulations require that a professional engineer (P. Eng) be retained, and the consultants disagreed on the P. Eng. specification. Consultant Rob Cyr begins by saying:

"I am a huge fan of independent 3<sup>rd</sup> party monitoring. However, there is no point in implementing that if all of a sudden. . . blasting contractors start asking around about 3<sup>rd</sup> party monitoring and [P. Eng's] say 'oh yes, we can do that' and it's a guy that works out of his basement . . .goes out to buy a seismograph, which you can do for eight grand, and now he's monitoring blasts. My recommendation is that it must be a professional engineer, licensed in the province, with a minimum of 5 to 10 years experience with explosives and blasting" (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011). However, the difficulty with the specification of a "P. Eng." written into the bylaw is the lack of experienced professionals in the province of BC. There are, however, many qualified specialists that are not registered professional engineers, but have over 15 years of blast consulting experience. Consultant Terry Matts explains:

"If you put the P. Eng. requirement in, I don't think you'll get any consultants. I wouldn't be eligible, Alastair who worked for Golder for many years as their consultant would not be eligible. Even Ron the president of the ISEE wouldn't be eligible" (T. Matts, pers. comm., October 16<sup>th</sup> 2011).

In response to the P. Eng. specification, Alastair Grogan also adds:

"You can make that change if you like, but you are not going to get eligible people. There are some *P* Eng's in the province that do it on the mining side, but very little or no experience in municipal blasting. Perhaps the wording in a bylaw could be "Blasting Engineer with experience in municipal blasting, or other person acceptable to the City Engineer" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

The lack of qualified professionals in the province of BC creates the risk of non-qualified professional engineers filling the market. The qualifications of the consultant should therefore be: a professional engineer or other person acceptable to the City, with at least 5 years of explosives and blast consulting experience.

### 5.4.6.4 Pre-blast surveys and notification radius

There was no opposition from blasting contractors that pre-blast surveys should be carried out before all blasting, if structures are within a specified radius of the blast. However, there is some disagreement on the radius in which pre-blast surveys must be performed. Rob Cyr begins by saying;

"There has to be minimum limits in the specs. You may get some engineers that say 'litter the place with seismographs and forget about the pre-blasts.' Pre-blast does eliminate a lot of the argument. For every damage investigation we get, between 80 and 90% of them we can go in and the cracks all show up in the video, its a 4 line email to the homeowner and its done. If you have to go back just to the vibration records, the science is still there but we will get calls back about 30% of the time that says 'I never noticed that crack before, but you're going to tell me that blasting, which I felt rattling my house and shook it five times a day didn't cause it?' And that's what a lot of these bylaws are trying to do, it's not science but its trying to eliminate the whole argumentative process and mitigation etc. So I think you have to put in a minimum distance, and I would say a minimum of 65 m, that's what we have found in our experience, because 65 m is going to catch 3 or 4 levels of houses in a densely populated area. At that point there your vibrations will have

attenuated fairly well to below 20 mm/s for typical urban blasting projects. If you take a look at OPS-120, you're going to notice that the pre-blast survey radius is 150 m (same as Sechelt). And what the city of Ottawa did was re-write their spec and basically copied Ontario provincial standard spec [OPS-120] and the reason they did that is the liability of course. They said if we write our own, then we're the authors of it and we assume liability. If we take the Ontario provincial standard, well that's a standard, and decided we are going to do inspections to 150 m. So then we got a big job down right in front of the American embassy in Ottawa, and it was \$150,000 worth of pre-blast surveys. So immediately everyone said 'well let's just do 65 m.' And then the next job came up and everyone said well the spec says 150 m, and the blasting contractor says well the last time we had a blast, you said 65 was fine, so why is 65 not fine now. And then there was another job – about an 8 km road to do, dense townhouses on both sides of the road, with a 150 m pre-blast radius, it was about a \$400,000 pre-blast bid. You could do no preblast fix every single person who complains (if there were a good vibration monitoring program in place) about a few cracks in their drywall and you'd still be at \$25,000, so why would you spend \$400,000 dollars? It's all about risk management. So it's good to have at least a minimum of both specs (pre-blast and monitoring). My recommendation is Pre-blast inspections to a minimum of 65 m, or as designated by the blasting consultant (so then it's his liability)" (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

Ron Elliott, on the other hand suggests that the pre-blast survey should be back calculated from anticipated PPV, which is performed by the consultant. He states:

"It should be related to predicted vibration level from the blast design. So it basically should be at the discretion of the engineer that is going to do the project and whether or not you are going to have an independent reviewer" (R. Elliot, pers. comm., October 16<sup>th</sup> 2011).

It is agreed by both consultant Rob Cyr and blasting contractor Ron Elliott, that the radius should be at the discretion of the engineer.

There were no recommendations from any of the participants at the ISEE's Western Canada AGM regarding the radius to which neighbours should be notified of future blasting. However, it is suggested that the neighbours should be given at least 48 hours notice. Alastair Grogan States:

"Has to be at least 48 hours and there has to be an exemption for emergency work. And it has to be written notification" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

In response to the method of back-calculation proposed by Blaster Ron Elliott, Consultant Rob Cyr explains the difficulty in this:

"If you are looking at downtown Ottawa, notifying to an expected PPV of 5 mm/s, with a maximum of 8 kg/delay you would be doing notification out to about 85 m. In that situation I would say notify out to about 150 m. That's what we have taken to be our rule

of thumb that will usually catch most of the people, whether it is low density or high density, even in downtown Ottawa. To notify to 150 m, you are looking at \$250. It almost should be based on the type of blasting rather than the area. If you are doing quarry shots, then notify to 500 m, if you are doing regular subdivision development, 150 m. So in a case like that 85 m is too low, 150 m would be appropriate. If a contractor is blasting only 5 kg/delay, the radius will be 50 m so he is going to be pre-blast surveying out to 65 m further than he has to notify. 150 m has worked well in our experience, but it wouldn't necessarily work for big quarry shots. If you do a 100,000 tonne quarry shot, you better notify people out to 500 m. A reputable blasting consulting will say this is a 100,000 tonne shot, I am going to get a million complaints if I don't go tell everybody what is going on here, so I am going to go out to half a km and make sure everybody is happy. My recommendation is that notifications shall be given to all homes / businesses to a minimum of 150 m and a maximum as designated by the consultant" (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

Similar to the recommended pre-blast radius, it is recommended that a minimum radius for notification is established in the bylaw, rather than simply relying on back-calculation from anticipated PPV.

## 5.4.6.5 Vibration / overpressure measurements by qualified monitor

Vibration and overpressure limits were presented to the blasters and consultants as 50 mm/s and 128 dB(L) respectively. It was unanimously recommended that the PPV shall not exceed the allowable limits that are dependent on frequency, and shown in Figure 4.

It was also recommended, as used in West Vancouver, that these measurements be made at the closest structure to the blast and the Engineer is present at the first blast. Throughout blasting, the blaster must forward the measurements to the engineer.

It is agreed unanimously, in some form, that there should be prescriptive requirements for the use of the seismograph. Alistair Grogan states:

"It is very important that both sets of guidelines for seismographs are used from the ISEE. One is the components of a seismograph, and the other is the standards for user responsibility, the correct method of setting up the seismographs, how it should be programmed, the data to be collected etc" (A. Grogan, pers. comm., October 16<sup>th</sup> 2011).

The most recent edition of the ISEE Handbook provides both performance specifications, and field practice guidelines for blasting seismographs.

In terms of the actual individual that carries out the monitoring, the consultants feel that some blasters are incapable of monitoring themselves, and dispute resolution would be difficult due to the bias of self-monitoring. Meanwhile, some blasters propose that they can easily monitor themselves. Blaster Ron Elliott contests:

"I think with today's seismographs, as long as the seismograph has been calibrated in the last year, the act of setting up the seismograph and collecting the data – I don't see why the blaster shouldn't be able to do that. But it should probably be stipulated that the seismograph must be set up using the guidelines established by the ISEE Blaster's Handbook. I don't think it's necessary to require third party monitoring. If there is an incident, then you could have a third party review of the seismograph data" (R. Elliot, pers. comm., October 16<sup>th</sup> 2011).

In the City of Ottawa, there are no regulatory requirements forcing blasters to retain independent monitoring, however an overwhelming majority of the blasting is monitored by consultants (Rob Cyr, pers. comm., August 22<sup>nd</sup> 2011). Rob Cyr states:

"I am a huge proponent of having a proper person doing the monitoring because the blasters primary role is to blast and ensure the safety of their site. Adding monitoring to their laundry list of tasks often results in less attention to the task and occasionally resentment of monitoring. . . here in Ottawa, consultants perform a majority of the blast monitoring now. . . what has forced them to do independent monitoring in the Ottawa area is that they (the blasters) saw the benefit from it in the end" (R. Cyr, pers. comm., August 22<sup>nd</sup> 2011).

This initiative has yet to occur in the province of BC, and regardless of monitoring being conducted by blasters, there are still phone calls being made to the City of Kelowna, and civil lawsuits between blasters and neighbours. It is therefore recommended that independent monitoring be conducted by a qualified individual. The City of Halifax defines a qualified individual in their blasting bylaw as;

"(i) an Engineer, a Geoscientist, or a person working under the supervision of an Engineer or a Geoscientist; (ii) trained on the proper use of the monitoring instruments by a representative of the manufacturer or distributor of the monitoring instruments or other competent individual, and; (iii) approved annually by the Municipality, but; (iv) shall not be the Blaster or the Applicant, or an employee of the Blaster or the Applicant;" (City of Halifax, 2003).

It is therefore recommended that blast monitoring shall be conducted by an independent qualified individual and that PPV shall not exceed the limits set forth in Figure 4, and overpressure shall not exceed 128 dB(L).

### 5.4.6.6 Hole-size restrictions for urban blasting

During a discussion regarding a solution mechanism to reduce the number of flyrock incidences province-wide, it was recommended that restrictions on hole-size may play a vital role in ensuring that safety is a priority over cost. Highlights from this discussion are shown below:

### Ron Elliott:

"If you looking into some of the major flyrock incidents that have occurred, it's contractors using 4" diameter holes in an urban environment, where they have no business using 4" holes in the middle of the city. And that's where blasters get into trouble. So perhaps there should be some limitation on hole size if you are in an urban environment" (R. Elliot, pers. comm., October 16<sup>th</sup> 2011).

### Terry Matts:

"Well that's what's in Sechelt, Sechelt is 2 <sup>3</sup>/<sub>4</sub> inch maximum hole size" (T. Matts, pers. comm., October 16<sup>th</sup> 2011).

### Ron Elliott:

"And that's a good step in the right direction. I think that if you are going to limit hole size in a municipality, it has to be tied to the distances from homes. Within a certain distance of homes, the maximum hole size is this, if you're this far from homes you can go to this size. But I don't think that Sechelt putting 2 <sup>3</sup>/<sub>4</sub> inch limit is the answer" (R. Elliott, pers. comm., October 16<sup>th</sup> 2011).

### Terry Matts:

"Yeah, it is too restrictive, that means anywhere in the municipality, even if they are out in the boonies, they can't use anything larger than 2 <sup>3</sup>/<sub>4</sub> It would have to be written as '2 <sup>3</sup>/<sub>4</sub> inch holes unless otherwise specified by a blasting consultant" (T. Matts, pers. comm., October 16<sup>th</sup> 2011).

Using the same argument that is proposed by Consultant Rob Cyr with regard to back calculation to determine radius for pre-blast surveys or notification radius, it is recommended that the hole size shall be left to the discretion of the consultant. As Consultant Terry Matts proposes, the maximum hole size shall not exceed 2 <sup>3</sup>/<sub>4</sub> inch holes unless otherwise specified by the consultant. This will also reduce the risk to the city as the responsibility is placed on the consultant.

### 5.4.6.7 Summary of amendments

Amendments made to the West Vancouver template, by blasters and consultants in BC and ON, are shown in Table 17. The first draft of the bylaw can be found in Appendix D. The 1<sup>st</sup> formal

draft of the bylaw was written using the categories in West Vancouver (Table 17), and specific wording and clauses for each of these categories from the Halifax Municipality Blasting Bylaw.

Category	Recommendations as per West Vancouver	Amendments (Development of 1st Draft)
Permit	<ul> <li>Insurance Proof (min \$5 M)</li> <li>Blaster Certificate Proof</li> <li>Pre-Blast Survey Report</li> <li>Control Measures / Blast Plan</li> </ul>	<ul> <li>Insurance Proof (\$5 M)</li> <li><i>Urban</i> Blasting Certificate Proof</li> </ul>
Consultant	A professional engineer who specializes in rock mechanics and has expertise in blasting in urban areas, and is independent of the Blaster and acceptable to the Director.	A professional engineer <i>or other person acceptable</i> <i>to the Director,</i> who specializes in rock mechanics and has expertise in blasting in urban areas <i>with 5</i> <i>years blast consulting experience</i> , and is independent of the Blaster.
Pre-Blast Survey	Radius as specified by the engineer.	<i>Minimum 65 m radius or</i> as specified by the <i>consultant.</i>
Notifications	Radius as per the engineer, with at least 48 hours notice.	<i>Minimum 150 m radius, or</i> as specified by the <i>consultant</i> , with at least 48 hours notice.
Vibration	Limit of 50 mm/s at closes structure.	USBM RI 8507 Blasting Level Criteria (Figure 4) at closest structure.
Overpressure	128 dB(L)	128 dB(L)
Monitoring Individual	During the course of blasting, the Blaster shall forward to the Engineer, all blast records and the Engineer shall review the blast records.	Blast monitoring shall be conducted by a Qualified Individual, as defined by the City of Halifax Blasting Bylaw.
Hole Size Restriction	None	2 <sup>3</sup> / <sub>4</sub> inch, unless otherwise specified by the consultant.

Table 17: Summary of amendments made by blasting contractors and consultants.

This draft was then sent to blasting contractors and consultants to ensure that the bylaw and its specific clauses were accurate, practical and stated effectively. These individuals include;

## **British Columbia**

- Ron Elliott (Pacific Blasting Inc. Contractor)
- Terry Matts (ExTc Consulting Ltd.)
- Alastair Grogan (Grogan Rock Consulting Ltd.)

### Ontario

- Rob Cyr and Moose Morin (Explotech Engineering Inc. Blasting Consultants)
- Lance McAnuff and Paul McAnuff (Golder VME Ltd. Blasting Consultants)

All contacted individuals responded with comments and suggestions. There were essentially two schools of thought, which differed between the British Columbia blasters and consultants alike and the Ontario consultants, on three main major aspects of the bylaw:

- 1. Retaining a consultant for every blast;
- 2. Requiring 3<sup>rd</sup> party monitoring / disallowing blasters to monitor themselves;
- 3. The way in which pre-blast surveys are conducted.

All of the above arguments are fuelled by their affects to contractor / consultant income and productivity. However, the bylaw is not written for the contractor or the consultant. Rather, the intention of the bylaw is to ensure that the best interests of the surrounding community are represented and as a secondary condition – minimize the affect to blaster productivity. That being said, a justification for each of these clauses was provided to the participating consultants and blasters. On November 30<sup>th</sup> 2011 some of the interviewed consultants and blasters met at the Pacific Blasting Corporate office in Burnaby, BC and their response to Draft 2 of the bylaw was the leave things the way they are. The final draft of the bylaw can be seen in Appendix E.

## 5.5 Recommendations

After consultation with municipal engineers, inspectors, blasting contractors and consultants, a generic bylaw, shown in Appendix E, has been developed and can be used by any interested municipality. This bylaw contains an appendix with a blasting information pamphlet that is designed to educate and inform home owners that may be affected by urban blasting (Appendix C).

It is recommended that municipalities:

- 1. Repeal their current bylaw, if present, and adopt the bylaw contained in Appendix E;
- 2. Modify or develop their own "Other Rights and Remedies," section in the bylaw and have a lawyer/solicitor that specializes in municipal law to review the entire bylaw;
- 3. Make minimal to no changes to any other sections of the proposed bylaw.

Furthermore, it is recommended that the Union of BC Municipalities consider a single harmonized blasting bylaw for all municipalities across the province.

This will effectively reduce the number of complaints made by neighbours to urban blasts, while minimizing the risk exposure, time and budget commitment to the municipality, and the effect on blaster productivity.

## 6 Conclusions and Recommendations

The adverse environmental effects of urban blasting, including vibration, overpressure and flyrock, have caused the industry to receive increasingly negative publicity in the province of British Columbia.

Blasting regulations at all relevant national, provincial/state, and municipal levels in Canada, United States and Australia were thoroughly investigated. A comparative analysis between existing regulations and incidents / complaints of vibration, overpressure and flyrock was performed. This analysis illustrated the need to amend provincial blasting regulations and to develop a municipal bylaw. Specific regulations were deduced from this analysis as well as interviews with municipal authorities, provincial regulators, blasting contractors and consultants nationwide.

## 6.1 Existing Blasting Regulations

The federal government of Canada regulates the safety and security of manufacturing explosives, their storage, import and transportation into and within the country. Site specific blasting regulations vary between provinces in Canada, and are generally aimed at the safety of construction workers. All provinces regulate flyrock with the exception of Prince Edward Island and the three territories. The remaining provinces, with the exception of British Columbia, specifically hold the employers, and in some cases, also the blaster, responsible for ensuring that flyrock does not affect surrounding persons or property. British Columbia is the only province in Canada in which the blasting regulations hold only the blaster, not the employer, responsible for flyrock incidences, and only the blaster can be fined or prosecuted. All existing flyrock regulations are written intentionally vague (i.e. "*must take necessary precautions*" etc.) in order to download the risk to trained employers / blasters, and this is consistent with flyrock regulations in the United States and Australia.

Newfoundland and Nova Scotia regulate flyrock, vibration and overpressure at the provincial level. The BC Ministry of Mines has effective measures to mitigate the adverse effects of vibration and overpressure on the neighbours of mines and quarries. Apart from municipal bylaws, this is the only regulating body with jurisdiction in BC that regulates urban blasting –

when a site defined as a mine or quarry intersects municipal boundaries. Thus there is a noticeable lack of provincial regulations governing urban blasting in BC.

At the municipal level, bylaws that regulate blasting in British Columbia are sparse, leaving 134 of the 157 municipalities unregulated. Those municipalities with blasting bylaws range from very poor, requiring only a permit without any regulations, to very extensive such as the blasting bylaws found in West Vancouver and Sechelt. Only 2% of the BC population lives within a jurisdiction that requires blasters to monitor the blast with a seismometer.

There are even fewer blasting bylaws in the province of Ontario; however a blast consulting firm that provides a public relations and blast monitoring services has proven that these activities will minimizes complaints within the province. Blasting companies have realized the advantage of retaining a blasting monitoring consultant in reducing frivolous and costly claims for damage.

The City of Halifax currently has the most prescriptive blasting bylaw in the country, which was implemented three months after a major flyrock incident in 2003.

## 6.2 Mitigation of Flyrock Incidents

In British Columbia, there have been 23 flyrock incidents in the past 10 years reported to WorkSafeBC. Thirteen (57%) of these incidents were caused by an absence of blasting mats, or improper use of blasting mats. In Ontario, there have been 6 flyrock incidents in the past 10 years reported to the Ministry of Environment, and only one incident was the result of an absence of blasting mats. The fundamental difference between Ontario and British Columbia provincial flyrock regulations is that:

- Ontario Ministry of the Environment fines the blasting company for every single flyrock incident, regardless of the cause.
- WorkSafeBC only penalizes the individual blaster, and is fined only after a repeated infraction.

It is recommended that flyrock remain the mandate of the provincial government, as the inclusion of blasting mats in a municipal bylaw would expose the municipality to unnecessary risk, since compliance with the provincial government regulations is already required.

It is concluded and confirmed by opinions of blasters, consultants and WorkSafeBC blasting inspectors alike, that the inability to link the company to the incident is one of the underlying causes of flyrock. Blasting companies keep their operational costs low by firing blasters after an incident, and hiring a new one. Therefore, it is also recommended that WorkSafeBC should amend their current regulation to include the employer as being a responsible party in the following manner:

21.66 (1) An employer and blaster must ensure that a blast is not fired until the necessary precautions for the protection of persons and property, including proper loading and stemming of holes, and where necessary, the use of cover for the blast or other effective means of controlling the blast or resultant flying material has been taken.

WorkSafeBC should also consider fining the blasting company for every flyrock incident, as is the case in Ontario.

## 6.3 Vibration and Overpressure Complaint Reduction

It is the general consensus among municipal engineers / inspectors, blasting contractors and consultants alike, that a very high percentage of damage claims are frivolous. In addition, it is also felt that most calls to the municipalities are related to an affected neighbour's irritation, lack of warning and a lack of understanding of blasting.

Many studies throughout the United States show that an effective communication bridge between a blast site and the surrounding community, as well as educating affected homeowners can drastically reduce the number of blasting-related complaints (up to 90% reduction in Nevada). It is recommended that an informative pamphlet, shown in Appendix C, which includes basic blasting education in layman's terms, be provided to the affected neighbours. The intent of the pamphlet is to reduce the number of vibration and overpressure complaints, as well as increase the accountability of blasters with respect to flyrock.

However, the pamphlet is ineffective without consistent regulations province-wide. It is clear that it is outside the mandate of both the Ontario Ministry of the Environment as well as WorkSafeBC to regulate the nuisances of blasting. Therefore, a harmonized blasting bylaw was developed that any municipality, struggling with blasting-related complaints, can easily adopt.
A comparative analysis was performed of the existing BC municipal blasting bylaws and their effectiveness in minimizing 1) time commitment by municipal engineers, 2) risk to the municipality, and 3) complaints. This quantitative analysis showed that if a municipality were to adopt a bylaw, the West Vancouver template is the most optimal. By incorporating specific clauses from the prescriptive City of Halifax bylaw, an initial draft of the harmonized blasting bylaw was developed and is shown in Appendix D. This draft was then presented to blasting contractors, regulators and consultants nationwide and their combined input was used to create the final draft that has a minimal affect on blaster productivity and cost.

It is recommended that municipalities:

- Repeal their current bylaw and adopt the proposed harmonized bylaw shown in Appendix E, which includes an information pamphlet / education plan.
- 2. Complete the "Other Rights and Remedies" section of the bylaw, and have a lawyer/solicitor that specializes in municipal law review the entire bylaw
- 3. Make minimal to no changes to any other sections of the proposed bylaw.

Furthermore, it is recommended that the Union of BC Municipalities consider a single harmonized blasting bylaw for all municipalities across the province.

It is proposed that the harmonized blasting bylaw, if implemented province-wide, coupled with the information pamphlet / education plan, will drastically reduce the number of frivolous and legitimate damage claims, as well as complaints to the city.

#### 6.4 Future Work

The recommended amendment to WorkSafeBCs' blasting regulations, as well as the recommended harmonized bylaw should be reviewed by an appropriate lawyer. Further, it is also recommended that the BC Municipal Insurance Association (MIA) as well as the Union of BC Municipalities (UBCM) consider the endorsement and dissemination of the harmonized blasting bylaw, in order to ensure consistency across the province.

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# Appendices

# Appendix A – Detailed Municipal Bylaws

Table 18: Detailed summary of blast related municipal bylaws in British Columbia

Municipality	Permit	Monitor	Blasting Mats	Notification of blasting	Comments	Pre-Blast Surveys	Time Restrictions	Insurance Limit	Blasting Consultant	Fine (not more than)	Comments Re: Flyrcok
Abbotsford	~	х	~	~	If within 100 m, notification in writing of blast time, duration of operation, explan of signals	х	Mon to Fri (8-4)	\$5,000,000	~	\$10,000	Blasting Mats / Other
Burnaby	✓	Х	Х	✓	If "in the vicinity," notification req'd within "reasonable" time	х	Mon to Sat (Day)	х	х	\$100	"Necessary Precautions"
Campbell River	✓	Х	Х	~	If "in the vicinity," notification req'd within "reasonable" time	Х	Sun to Fri (Day)	\$2,000,000	х	N/A	"Necessary Precautions"
Colwood	~	~	~	~	If "within 300 m" notification in writing describing work done, dates, signals, name / phone # of blasters and their insurance provider	<b>√</b> (60m)	Thurs (830 - 4) Fri (830 - 3)	\$5,000,000	~	\$750	"Blasting Mats or Clean or clean rock-free fill or sand"
Highlands	~	~	~	~	"Written notification for dwellings within 100 m"	х	Mon to Sat (8-4)	\$2,000,000	~	\$5,000	"Blasting Mats or Clean or clean rock-free fill or sand"
Invermere	~	х	х	~	"24 hr Written notification to dwellings within 100m, school district within 300 m"	х	х	\$5,000,000	х	\$10,000	"Necessary Precautions"
Metchosin	~	~	~	~	"Written notification for dwellings within 100 m"	х	Mon to Sat (8-4)	\$2,000,000	х	\$5,000	"Blasting Mats or Clean or clean rock-free fill or sand"
Nanaimo	Х	Х	Х	Х	Х	Х	Mon to Sat (7-5)	Х	Х	Х	Х
North Cowichan	~	✓ (PPV < 50 mm/s)	х	~	"24 hr Written notification to dwellings within 300m"	✓ (30m)	Mon to Sat (7-6)	\$2,000,000	х	N/A	"Necessary Precautions"
North Vancouver	~	x	~	~	" notification for dwellings within 100 m"	х	Mon to Sun (7-8)	\$1,000,000	x	\$200	"Blasting mat or sufficient material"
Parksville	х	х	х	х	х	х	Mon to Sat (7-5)	х	х	х	х

Municipality	Permit	Monitor	Blasting Mats	Notification of blasting	Comments	Pre-Blast Surveys	Time Restrictions	Insurance Limit	Blasting Consultant	Fine (not more than)	Comments Re: Flyrcok
Peachland	~	х	х	х	x	х	х	х	Х	\$1,000	Х
Port Coquitlam	~	х	~	~	"Notification to dwellings within 100m, school district within 300 m"	х	Mon to Fri (8-4)	\$5,000,000	х	\$2,000	"Suitable blasting mat or some material or device sufficent to provide precautions"
Prince Rupert	~	х	х	~	" 24 hr notification for dwellings within 100 m"	х	Mon to Sat (9-9)	\$250,000	х	N/A	"Necessary Precautions"
Rossland	~	х	~	x	х	~	Mon to Sat (8-5)	\$2,000,000	х	\$5,000	"Suitable blasting mat or some material or device sufficent to provide precautions"
Saanich	✓	Х	Х	Х	Х	Х	Mon to Sat (8-5)	\$2,000,000	Х	> \$150	Х
Sechelt	~	✓ (PPV < 50 mm/s)	~	~	"Written notification for dwellings within 150 m"	✓ (150m)	Mon to Sat (as per municipal director)	\$5,000,000	✓ Required	\$10,000	"Suitable blasting mat or some material or device sufficent to provide precautions"
Sooke	~	х	х	~	"24 hr Written notification to dwellings within 100m, school district within 300 m"	х	Mon to Sat (8- 4:30)	\$2,000,000	х	N/A	"Necessary Precautions"
Squamish	✓	х	$\checkmark$	Х	Х	Х	Х	\$1,000,000	х	N/A	"Mats or other type of protective material"
Surrey	$\checkmark$	Х	Х	Х	Х	Х	Х	\$3,000,000	Х	\$500	Х
Terrace	Х	Х	Х	Х	Х	Х	Mon to Sat (8-5)	Х	Х	х	Х
Victoria	~	х	x	~	"Written notification (work dates, safegaurds, signals, names and # of blaster and insurance provider) for dwellings within 100 m"	х	Mon to Fri (7-7)	\$5,000,000	х	\$10,000	х
West Vancouver	~	✓ (PPV < 50 mm/s)	~	~	"Written notification for dwellings within 150 m and schools and hospitals within 300 m"	~	Mon to Fri (as per noise bylaw)	\$5,000,000	✓ Required	\$10,000	Х
West Kelowna	~	x	х	<ul> <li>Image: A second s</li></ul>	"Notificaiton to neighbours as per approval of municipal"	x	x	x	x	x	x
Good Neighbour Pylow					Noi	se Bylaw	Blacting		sting Bylaw		

Good-Meighbour Bylaw

Noise Bylaw

Blasting Bylaw

# Appendix B – Causes of Canadian Flyrock Incidents

Incident Report Number	British Columbia
2007101920106	Misfire
2007117640470	loaded blast hole intersected shear hole
2006107970289	No Blasting mats
2008156240138	No Open Face (blast mats went 33 m in air)
2009119700102	No blast mats used (100 m)
2003010009	Too much explosives (500 m)
2005112130039	Damaged Protective Berm
2005117650394	Flyrock escaped blasting mat
2007116180061	Flyrock escaped blasting mat
2008163270023	Flyrock escaped blasting mat
2009155980330	Misfire - Could not fire
2007114550149	Poor Design / Loading Previously loaded holes
2004060313	No blast mats used (100 m)
2006037470243	No Blast Mats used (150 m)
2006156160235	Blaster Not Oriented to Surroundings (Poor Design)
2006037470357	No Blasting Mats when there should have been
2008137102606	No mats used even though contract req'd them. No Collar
2008107970172	No mats used with houses 90 m away at the bottom of slope
2009137102733	No Blasting Mats used
2008114550066	Misfire
2006107970289	Top Primed and no Mats
2008155980132	Flyrock escaped blasting mat
2007157560528	No Blasting Mats
MOE Incident Reports	ONTARIO
2007 Castonguay Inc.	No blasting mats (90 m)
2008 Castonguay Inc.	Poor Design (too much explosives - hit house 500 m away)
2004 Consbec Inc.	Insufficient Burden
2008 Dyno Nobel Inc.	Poor Design Improper Sequencing
2010 Rene Leroux	Inexperienced Blaster
2009 Sernoskie Bros Ltd.	Insufficient Burden
Newspaper Reports	Yukon Territory
2008 Whitehorse	Poor Design (unaware of nearby residents)
Newspaper Reports	Nova Scotia
2003 Halifax	No Reason Reported

Table 19: Causes of Canadian flyrock incidents reported between 2001 and 2011

	BC	ON
Blasting mats not used		
when necessary	10	1
Blasting mats improperly		
placed	3	0
Poor Design	7	5
No Cause of Flyrock		
Reported	0	0
Misfire	3	0

#### **Appendix C – Education Plan / Informative Pamphlet**

#### NOISE

Blasting noise creates two common concerns: 1) the nuisance of the sound (measured in dB), and 2) the pressure that is exerted on a home from the air blast (which causes the noise). The noise limit for your home is 128 dB. This noise level is 6 dB lower than the recommended limit by the US Bureau of Mines, and has a pressure equivalence of an average windy day.

The following table compares this safe limit to other occupational health and safety limits.

Noise Level (dB)	Sound Limits	Wind Speed Equivalence (km/hr)
90	Max. for 8 hours of continuous exposure	3.5
115	Complaints likely for 15 minutes of continuous exposure	15
120	Pain threshold for continuous exposure	20
128	Recommended limit for impulsive sound produced by blasting	32
134	Recommended Safe limit for impulsive sound by the USBM	46
140	Maximum for impulsive sound (blasting) — threshold of pain	65
150	Some windows break	115
170	Most windows break	362
180	Structural damage	644

#### FLYROCK

Flyrock is rock discharged onto your property from the blast site. It is a result of poor blasting practice, or unforeseen geological conditions. The blaster must take every precaution to ensure that flyrock is minimized. If flyrock were to land on your property, the blaster would be in violation of Section 21.66 (1) of the provincial Occupational Health and Safety Act. Violation of this section results in the suspension of the blaster's certificate and, in some cases, a fine. Call WorkSafeBC claims centre at 1-888-967-5377 to report flyrock that has landed on your property.

#### WHAT IS THIS THING ON MY LAWN?

Although a technician will check with you before placing a seismograph on your property, the following is a brief description of what a seismograph does and where it *should* be placed. A seismograph is used to monitor ground vibrations (mm/s) and noise (dB). The device is set up before blasting commences. It is automatically activated, or triggered, by a vibration "event" and data are stored digitally and is then downloaded to a computer. A typical seismograph is shown in below:



Typical Seismograph (www.instantel.com/products)

Blasters are sometimes accused of improper installation in order to produce results in their favour. Guidelines on where and how the seismograph should be set up are:

- The seismograph should be placed at the closest point of the closest structure to the blast. Vibration levels are dependent on distance. Therefore the closest house to the blast usually experiences the highest vibrations, and it is not necessary to measure vibrations at every home.
- The geophone, which measures vibration, should be buried underground. In cases where this is not possible, it should be placed on a level surface with a sandbag (or other weight) placed over top of it.
- The geophone arrow (shown above), and the microphone should both be directed towards the location of the blast.

# Urban Blasting in British Columbia

A Guide for People Living Near Blasts



#### PURPOSE

This pamphlet has been delivered to your home to answer any preliminary questions regarding the blasting that will be conducted near your property.

Blasting is required to excavate rock for the project described below:

Blasting will commence on:

and is expected to be completed by:

For your convenience, the blasting contractor will make every attempt to ensure blasts are fired between:

\_\_\_\_\_ and \_\_\_\_\_ Mon. to Fri. However, for safety reasons, blasting may be conducted outside of these times.

#### SIRENS

As part of the regulation requirements set forth by WorkSafeBC, you will hear the following safety sirens:

- 1. Before the blast: 12 short whistles
- 2. After two minutes elapse: Blast Fired!
- Once area is cleared, and site is deemed safe to return: A long 5-second whistle is sounded.

If you have any questions regarding the nature of this project, please contact:

of

Tel:

#### SAFE BLASTING PRACTICE

#### Background

Blasting utilizes explosive energy to break rock. The figure below shows a typical blast plan:



Each number represents a hole, and each hole is filled with a certain weight of explosives. The holes marked with the same number are detonated at the same time, and between numbers there is a specific delay (typically 25 milliseconds). Time delays between holes of explosives are used to ensure proper rock fragmentation and to minimize ground vibrations. There is usually a "free-face." After '1' is shot, B-B' becomes a new free face and so on. By opening up the free face, rock is projected into a controlled pile, perpendicular to the dotted lines.

#### Urban Blasting

In urban blasting, at the discretion of the certified blaster, the following precautions can be taken to protect neighbours and their homes:

Use smaller shots (reduce the number of holes)

- Reduce weight of explosives per delay
- 3. If possible, ensure the "free-face" points away from
- homes 4. Use blasting mats, or other cover (such as soil)
- Use blasting mats, or other cover (such as soli) placed over the blast holes to ensure that no flyrock is discharged off site
- Postpone blasts until the wind has reached a favourable speed and direction.

#### BLASTING COMPLAINTS

There are three common complaints that stem from urban blasting. These are ground vibrations, loud noises, and rock landing on a neighbouring property.

#### VIBRATIONS

Vibration is measured as *Peak Particle Velocity (PPV)*. The amount of vibration, or the PPV magnitude, depends on the distance your home is from the blast and the weight of explosive per delay. It is measured in mm/s. PPV does not represent how far the ground moves, but rather the speed at which the ground moves. A conservative "safe limit" for PPV is 50 mm/s. The following table compares this safe limit to everyday occurrences in your home, as well as the damage thresholds for residential structures.

PPV (mm/s)	Vibration Equivalence
0.5	Slightly perceptible
0.8	Walking
7.1	Jumping
12.7	Door Slams
22.4	Pounding Nails
50	Safe limit
76	Daily environmental changes to your home (such as temperature cycles)
137	Minor damage to typical residential structures
183	Major damage to typical residential
229	90% probability of minor damage

The 50 mm/s limit is only 35% of the damage threshold and only 65% of the effects of daily environmental changes to your home. This limit is used to minimize damage to the structure of your home. However, you must ensure that delicate objects that are precariously mounted in your home are safely stowed as they may shift or topple as a result of very low vibration levels.

# Appendix D – First Draft of Harmonized Blasting Bylaw

# [Interested] Regional Municipality By-Law Number [00000] Respecting Blasting

# General

#### Number and Short Title

1. This By-law shall be known as By-law Number [00000] and shall be cited as the "Blasting By-law."

## Jurisdiction

2. The Blasting By-law contains laws that must be complied with, in addition to those blasting laws that are regulated by the provincial and federal governments.

#### Appendices

3. Appendix "A" and Appendix "B" form part of the By-law.

## Definitions

- 4. In this By-law:
  - a) *"Affected Community"* means all properties within a distance of 150 m from the Blasting Area, unless increased by the Consultant;
  - b) *"Air Blast"* means the airborne shock wave which results from Blasting, which may or may not be audible, measured in decibels on a linear scale (dBL);
  - c) "Applicant" means a person who has applied for a Blasting Permit under this By-law;
  - d) *"Blaster"* means a person named on a valid Urban Blasting Certificate issued by the Province of British Columbia;
  - e) *"Blasting"* means the handling, preparation and use of explosives, but does not include delivery or storage by a properly qualified person in accordance with Federal and Provincial Law;
  - f) *"Blasting Area"* means the zone in which holes will be loaded with explosives to be detonated;
  - g) *"Consultant"* means a Professional Engineer, or other person acceptable to the Inspector, that specializes in rock mechanics and has expertise in blasting in urban areas with at least 5 to 10 years blast consulting experience, and is independent of the Blaster.
  - h) *"Inspector"* means the person appointed by the Chief Administrative Officer of the Municipality to be the Inspector of Blasting or their designate;

- i) *"Municipality"* means the [Interested] Regional Municipality;
- j) *"Particle Velocity"* means the measure of the intensity of ground vibration, measured in millimeters per second;
- k) "Qualified Monitor" means a person who is;
  - i. the Consultant, or a person working under the supervision of a Consultant;
  - ii. trained on the proper use of the monitoring instruments by a representative of the manufacturer or distributor of the monitoring instruments or other competent individual, and;
  - iii. approved annually by the Municipality, but;
  - iv. shall not be the Blaster or the Applicant, or an employee of the Blaster or the Applicant;

#### **Blasting Permit**

5. (1) No person shall carry out or cause to be carried out Blasting in the Municipality without a Blasting Permit first having been obtained from the Inspector.

(2) A Blasting Permit shall not be issued to an Applicant unless the Applicant is a Blaster, the Applicant has a Blaster in his/her employ, or the Applicant has a contract with a Blaster in respect of the work for which the Blasting Permit is intended.

(3) Notwithstanding subsection (1), the inspector may give permission for Blasting without a Blasting Permit in an emergency situation.

#### **Hours of Blasting**

6. (1) No person shall carry out or cause to be carried out Blasting on a Saturday, a Sunday, Remembrance Day, or a holiday as defined in the Interpretation Act, R.S.N.S. 1989, c.35, as amended from time to time.

(2) No person shall carry out or cause to be carried out Blasting after 6:00 p.m. or before 8:00 a.m., Monday to Friday inclusive.

(3) No person shall carry out or cause to be carried out Blasting after official sunset.

(4) Notwithstanding to subsections (1), (2), and (3), the council of the Municipality may allow the Inspector to issue a Blasting Permit to carry out Blasting on weekends or holidays if such operation is in the interest of public convenience. In such cases, the hours of Blasting shall be limited to 10:00 a.m. to 6:00 p.m. and before official sunset.

## Limits

## Particle Velocity

7. No person shall carry out or cause to be carried out Blasting which results in a Particle Velocity measured at the closest structure to the blast which exceeds the limits set out in Figure 1, unless otherwise specified by the Consultant.





#### **Maximum Air Blast**

8. No person shall carry out or cause to be carried out Blasting which results in an Air Blast measured at the closest structure to the blast which exceeds 128 decibels as measured on the linear scale.

# **Activities During Blasting**

## **Pre-Blast Survey**

- 9. (1) No person shall carry out or cause to be carried out Blasting unless a pre-blast survey is completed on every structure within 65 m of the Blast Area unless increased by the consultant, and which meets the following requirements.
  - a) the pamphlet provided in Appendix A, containing project description / location, the blasting contractor's name, the name of the firm conducting the survey, and an approximate start and completion date for the project is distributed to all property owners in the area to be surveyed;
  - b) appointments are made and the survey is carried out in a timely manner;
  - c) each property owner is contacted in person and if the homeowner cannot be contacted, notification is to be sent via registered mail, advising the owner who to contact to schedule an appointment;

- d) the survey consists of high quality video photography of the exterior of the structure, in reproducible format, and which shows an overview of every side of the structure, and includes details of any deficiencies noted at any location on the exterior;
- e) the survey shows fences, sidewalks, trees, and other similar features if the structure is within 15 m of the construction site;
- f) video surveys are carried out on the interior of the structure with the owner's consent;
- g) the video record is supplied for review to the property owner upon request;

(2) Notwithstanding subsection (1) a pre-blast survey shall not be required before a Blasting Permit is issued in the event the property owner cannot be contacted or refuses entry to the property.

#### Notification

- 10. (1) No person shall carry out or cause to be carried out Blasting unless the pamphlet (provided in Appendix A) is delivered by hand after the Blasting Permit is issued and at least two days (48 hours) prior to the commencement of Blasting, to every property owner or business within the Affected Community which shall contain:
  - a) the name of the person or company responsible for Blasting, including a contact person and telephone number;
  - b) the intended date and time when Blasting shall commence and its expected duration, and;
  - c) the location of Blasting.

(2) No person shall carry out or cause to be carried out Blasting within 300 m of a school, hospital, or other health care facility unless:

- a) such notice as required by subsection (1) has been given to the senior administrator of the school, hospital, or other health care facility, and;
- b) the senior administrator is also informed at least 2 hours prior to each blast.

#### **Blaster Required**

11. No person shall carry out or cause to be carried out Blasting unless:

- a) the Blasting is under the care and control of a Blaster, and;
- b) a Blaster is on the work site and wears visual identification at all times while the site is deemed a Blasting Area.

#### **Blast Monitoring**

12. (1) No person shall carry out or cause to be carried out Blasting unless:

a) a Qualified Monitor monitors every blast;

b) blast monitoring equipment and procedures meet the standards of Appendix B.

#### Hole Size

13. No person shall carry out or cause to be carried out Blasting where blast holes exceed a diameter of 70 mm, unless increased by the Consultant and approved in writing by the Inspector.

#### Submit Records

14. (1) During the course of blasting, the consultant shall review the blast records and confirm to the Inspector, if requested, that blasting is being carried out in accordance with the specifications of this by-law, and shall immediately report any problems, unusual circumstances or inconsistencies to the Inspector.

(2) The Consultant will report, within 24 hours to the Inspector, any instance when, and under what circumstances, vibrations and/or Air Blast exceeded the specified maximum limits. This report will include a written explanation for the excessive Air Blast and Particle Velocity level(s) as well as a description of corrective actions.

## Administration

## **Blasting Permit Application**

- 15. The Applicant for a Blasting permit shall make written application on a form provided by the Inspector.
- 16. The application shall contain the following information:
  - a) the Applicant's name, address, telephone number, and type of business;
  - b) a contact person's name, title, and telephone number;
  - c) a description of the scope of work, including purpose for which Blasting is required;
  - d) the date upon which work is proposed to commence and the probable duration;
  - e) a copy of a valid urban blasting certificate issued by the Worker's Compensation Board to the blaster who will undertake the work;
  - f) a certificate of insurance on a form acceptable to the Inspector which provides a policy of commercial general liability for bodily injury and property damage in the amount of \$5,000,000 per occurrence which includes the [Interested] Regional Municipality as an additional insured, a cross liability clause and a Blasting endorsement for the full limits of the policy; and
  - g) such other information as the Inspector may require.

# **Other Rights and Remedies**

Terms and Conditions, penalties, duration, fees etc. as required by [Interested] Municipalities

Done and passed in Council this [#] day of [Month], 2012

MAYOR

ACTING MUNICIPAL CLERK

# Appendix A (of bylaw)

Notification – Informative Pamphlet

# Appendix B (of bylaw)

Standards and Requirements for Monitoring as per ISEE Handbook 18<sup>th</sup> ed. (ISEE, 2011)

# Appendix E – Final Draft of Harmonized Blasting Bylaw

# [Interested] Regional Municipality By-Law Number [00000] Respecting Blasting

# General

#### Number and Short Title

1. This By-law shall be known as By-law Number [00000] and shall be cited as the "Blasting By-law."

#### Jurisdiction

2. The Blasting By-law contains laws that must be complied with, in addition to those blasting laws that are regulated by the provincial and federal governments.

#### Appendices

3. Appendix "A" and Appendix "B" form part of the By-law.

#### Definitions

- 4. In this By-law:
  - a) *"Affected Community"* means all properties within a distance of 150 m from the Blasting Area, unless adjusted by the Consultant;
  - b) *"Air Overpressure"* means the airborne disturbance which results from Blasting, which may or may not be audible, measured in linear decibels (dBL);
  - c) "*Applicant*" means a person who has applied for a Blasting Permit under this By-law;
  - d) *"Blaster"* means a person named on a valid Urban Blasting Certificate issued by the Province of British Columbia;
  - e) *"Blasting"* means the handling, preparation and use of explosives, but does not include delivery or storage by a properly qualified person in accordance with Federal and Provincial Law;
  - f) *"Blasting Area"* means the zone extending 15 m of all directions from the place in which holes will be loaded with explosives to be detonated;
  - g) "*Consultant*" means a Professional Engineer, or a person with other relevant qualifications or reputation acceptable to the Inspector, that has expertise in blasting in urban areas with at least 5 years blast consulting experience, and is independent of the Blaster and the explosives manufacturer or distributor.
  - h) *"Inspector"* means the person appointed by the Chief Administrative Officer of the Municipality to be the Inspector of Blasting or their designate;

- i) *"Municipality"* means the [Interested] Regional Municipality;
- j) *"Particle Velocity"* means the measure of the intensity of ground vibration, measured in millimeters per second;
- k) "Qualified Monitor" means a person who is;
  - i. the Consultant, or a person working under the supervision of a Consultant;
  - ii. trained on the proper use of the monitoring instruments by a representative of the manufacturer or distributor of the monitoring instruments or other competent individual, and;
  - iii. shall not be the Blaster or the Applicant, or an employee of the Blaster or the Applicant;

#### **Blasting Permit**

5. (1) No person shall carry out or cause to be carried out Blasting in the Municipality without a Blasting Permit first having been obtained from the Inspector.

(2) A Blasting Permit shall not be issued to an Applicant unless the Applicant is a Blaster, the Applicant has a Blaster in his/her employ, or the Applicant has a contract with a Blaster in respect of the work for which the Blasting Permit is intended.

(3) Notwithstanding subsection (1), the inspector may give permission for Blasting without a Blasting Permit in an emergency situation.

#### **Hours of Blasting**

6. (1) No person shall carry out or cause to be carried out Blasting on a Saturday, a Sunday, Remembrance Day, or a holiday as defined in the Interpretation Act, R.S.N.S. 1989, c.35, as amended from time to time.

(2) No person shall carry out or cause to be carried out Blasting outside of daylight hours.

(3) Notwithstanding to subsections (1) and (2), the council of the Municipality may allow the Inspector to issue a Blasting Permit to carry out Blasting on weekends or holidays if such operation is in the interest of public convenience. In such cases, the hours of Blasting shall be as per 6 (2).

# Limits

## **Particle Velocity**

7. No person shall carry out or cause to be carried out Blasting which results in a Particle Velocity measured at the closest structure to the blast which exceeds the limits set out in Figure 1, unless otherwise specified by the Consultant.





## **Maximum Air Overpressure**

8. No person shall carry out or cause to be carried out Blasting which results in an Air Overpressure measured at the closest inhabited building to the blast which exceeds 128 dB(L), measured on the linear scale, unless otherwise specified by the Consultant and accepted by the Inspector.

# **Activities During Blasting**

#### **Pre-Blast Survey**

- 9. (1) No person shall carry out or cause to be carried out Blasting unless a pre-blast survey is completed on every structure within 65 m of the Blast Area unless adjusted by the Consultant, and which meets the following requirements.
  - a) Notification, containing project description / location, the blasting contractor's name, the name of the firm conducting the survey, and an approximate start and completion date for the project, is distributed to all property owners in the area to be surveyed;
  - b) appointments are made and the survey is carried out in a timely manner and in advance of the commencement of Blasting on the project;
  - c) each property owner is contacted in person and if the homeowner cannot be contacted, notification is left in the mailbox advising the owner who to contact to schedule an appointment;

- d) the survey consists of high quality video photography, unless still photographs are preferred by the property owner, of the structure, in reproducible format, and which provides an overview of the entire structure, interior and exterior, provided consent is given by the property owner or his/her respective representative;
- e) the survey shows fences, sidewalks, trees, and other similar features adjoining the property;
- f) the video record may be reviewed by the property owner upon request;

(2) Notwithstanding subsection (1) a pre-blast survey shall not be required before a Blasting Permit is issued in the event the property owner cannot be contacted after a minimum of four visits to the property, with a maximum of one visit per day, or refuses entry to the property.

## Notification

- 10. (1) No person shall carry out or cause to be carried out Blasting unless the pamphlet (provided in Appendix A) is delivered by hand after the Blasting Permit is issued and at least two days (48 hours) prior to the commencement of Blasting, to every property owner or business within the Affected Community which shall contain:
  - a) the name of the person or company responsible for Blasting, including a contact person and telephone number;
  - b) the intended date and time when Blasting shall commence and its expected duration, and;
  - c) the location of Blasting.

(2) No person shall carry out or cause to be carried out Blasting within 300 m of a school, hospital, or other health care facility unless:

- c) such notice as required by subsection (1) has been given to the senior administrator of the school, hospital, or other health care facility, and;
- d) the senior administrator is also informed at least 2 hours prior to each blast.

## **Blaster Required**

11. No person shall carry out or cause to be carried out Blasting unless the Blasting is under the care and control of a Blaster.

## **Drilling Dust Control**

12. No person shall carry out or cause to be carried out Blasting without the use of an acceptable dust collection system as part of the drill machine.

## **Blast Monitoring**

13. (1) No person shall carry out or cause to be carried out Blasting unless:

a) a Qualified Monitor monitors every blast;

b) blast monitoring equipment and procedures meet the standards of Appendix B that refers to Appendices D and E of the ISEE Blasters Manual, 18 ed.

#### **Hole Size**

14. No person shall carry out or cause to be carried out Blasting where blast holes exceed a diameter of 70 mm, unless adjusted by the Consultant and approved in writing by the Inspector.

#### **Submit Records**

15. (1) During the course of blasting, the Consultant shall review the blast records and confirm to the Blaster and/or Inspector, if requested, that blasting is being carried out in accordance with the specifications of this by-law, and shall immediately report any problems, unusual circumstances or inconsistencies to the Blaster and/or Inspector.

(2) The Consultant will report, within 24 hours to the Blaster and/or Inspector, any instance when, and under what circumstances, vibrations and/or Air Overpressure exceeded the specified maximum limits. This report will include a written explanation for the excessive Air Overpressure and Particle Velocity level(s) as well as a description of corrective actions.

# Administration

#### **Blasting Permit Application**

- 16. The Applicant for a Blasting permit shall make written application on a form provided by the Inspector.
- 17. The application shall contain the following information:
  - h) the Applicant's name, address, telephone number, and type of business;
  - i) a contact person's name, title, and telephone number;
  - j) a description of the scope of work, including purpose for which Blasting is required;
  - k) the date upon which work is proposed to commence and the probable duration;
  - 1) a copy of a valid urban blasting certificate issued by the Worker's Compensation Board or the BC Ministry of Mines to the blaster who will undertake the work;
  - m) a certificate of insurance on a form acceptable to the Inspector which provides a policy of commercial general liability for bodily injury and property damage in the amount of \$5,000,000 per occurrence which includes the [Interested] Regional Municipality as an additional insured, a cross liability clause and a Blasting endorsement for the full limits of the policy; and
  - n) such other information as the Inspector may require.

# **Other Rights and Remedies**

Terms and Conditions, penalties, duration, fees etc. as required by [Interested] Municipalities

Done and passed in Council this [#] day of [Month], 2012

MAYOR

ACTING MUNICIPAL CLERK

Appendix A of Bylaw Notification – Informative Pamphlet (located in Appendix C of thesis) Appendix B of Bylaw Standards and Requirements for Monitoring as per ISEE Handbook 18<sup>th</sup> ed. (ISEE, 2011)