

The Impact of Blasting Quarries & The Need For Adequate Setbacks (17-Nov-20)

(see <https://intval.com/articles/Flyrock-and-Other-Impacts-from-Quarry-Blasting-Operations.pdf> and <https://intval.com/articles/Flyrock-and-Other-Impacts-Supplement-1.pdf>)

TABLE OF CONTENTS

<i>SECTION I</i>	2
Municipalities Can Impose Setback Requirements, Restrict the Location of Pits and Quarries or Prohibit Pits and Blasting Quarries For Health and Safety Reasons	2
Quarry Setback/Buffer Zone Requirements in Various Jurisdictions.....	4
Incidences of Flyrock Unreported or Uninvestigated.....	6
Flyrock Is Inevitable Wherever Rock Is Blasted.....	9
Why Is Flyrock So Dangerous?.....	12
DEP Chief Regulator Informs Explosives Engineers of Dangers of Flyrock	14
Flyrock Statistics Cited by Different Sources.....	14
Examples of Flyrock’s Greatest Hits!.....	16
Examples of Known Repeat Flyrock Offenders.....	17
Empirical Methods of Calculating Flyrock Phenomenon Not Accurate	18
Blasting Standards Inadequate to Avoid Structural Damage to Nearby Residences and Blast Vibration Complaints.....	19
Quarry Blast Initially Mistaken for Earthquake.....	22
Quarry Blast Vibrations Cause Property Damage and Impact Residents’ Health.....	22
Blasting Within Regulatory Limits Offers No Assurance Against Property Damage.....	23
Blasting Supervisor Fired Rather Than Put People and Property At Risk.....	24
Proposed Quarry A Potential Nuisance – Injunction Imposed Against Blasting.....	25
Homeowners’ Wells Near Dewatering Aggregate Pit Impacted.....	25
Balancing Aggregate Extraction Against the Need to Avoid Unacceptable Impacts.....	27
Neighbours Attribute House Damages to Blasting at a Nearby Quarry	29
Quarry Permit Denied in Part Due to Blasting and Flyrock	29
<i>SECTION II – DOCUMENTED FLYROCK INCIDENTS</i>	33

SECTION I

Municipalities Can Impose Setback Requirements, Restrict the Location of Pits and Quarries or Prohibit Pits and Blasting Quarries For Health and Safety Reasons

In *Uxbridge Township v. Timber Brothers*,¹ the court ruled that the *Ontario Planning Act* explicitly provided for the power for municipalities to make by-laws prohibiting pits and quarries in certain areas. Uxbridge Township had imposed a by-law providing land uses and residential setbacks for pits and quarries. A further by-law regulated the operation of pits and rehabilitation and safety requirements.²

The court interpreted this to allow only the prohibition of new pits, not the regulation of existing ones. The court considered that the Municipal Act in Ontario provided the power to regulate the “operation” of pits and quarries. The operator challenged an Uxbridge Township bylaw on (among other grounds) the basis that the province already regulated quarry rehabilitation and setbacks. The court found that the Municipality could provide additional setbacks:

The provincial legislation does no more than set the minimum set-back requirements or standards and in no way attempts to restrict the right of a municipality to enhance these standards. This the municipality may do provided it acts within its delegated legislative powers and does not enact provisions in by-laws which are inconsistent with statutory provisions.

The court held that municipal setbacks that were less than those provided for in provincial legislation were invalid.

The court allowed an injunction against the pit based on the other portions of the gravel regulation bylaw.

*This case was referenced by the Supreme Court of Canada in *Spraytech*³ specifically for the proposition that municipalities may regulate the environment more than the province does.*

The SCC went on to hold that general welfare provisions in municipal statutes, including in Alberta [and Ontario], authorize environmental regulation within a municipality relating to pesticides, notwithstanding the existence of provincial laws relating to the same subject.

Under the *Ontario Municipal Act*, the province can delegate to a municipality the right to legislate on a prescribed range of matters. They include the following:

¹ [1975] O.R. (2d) 484 (Ont. C.A.) Leave to appeal to Supreme Court of Canada Dismissed. 1975 CanLII 507 (ON CA), <<http://canlii.ca/t/g1cpz>>, retrieved on 2020-11-05.

² Laura Bowman, Staff Counsel, Environmental Law Centre, “Gravel can be the pits!” Webinar – September 22, 2010, <https://elc.ab.ca/media/7529/GravelPitsHandout.pdf>.

³ 114957 *Canada Ltée (Spraytech, Société d'arrosage) v. Hudson (Town)*, 2001 SCC 40 (CanLII), [2001] 2 SCR 241, <<http://canlii.ca/t/51zx>>, retrieved on 2020-11-05

By-laws

- (2) A single-tier municipality may pass by-laws respecting the following matters:
1. Governance structure of the municipality and its local boards.
 2. Accountability and transparency of the municipality and its operations and of its local boards and their operations.
 3. Financial management of the municipality and its local boards.
 4. Public assets of the municipality acquired for the purpose of exercising its authority under this or any other Act.
 5. Economic, social and environmental well-being of the municipality, including respecting climate change.
 6. Health, safety and well-being of persons.
 7. Services and things that the municipality is authorized to provide under subsection (1).
 8. Protection of persons and property, including consumer protection.
 9. Animals.
 10. Structures, including fences and signs.
 11. Business licensing. 2006, c. 32, Sched. A, s. 8; 2017, c. 10, Sched. 1, s. 1.

In addition to the delegation of the above-noted specific powers, Section 102 of the Ontario *Municipal Act* empowers municipalities with an “omnibus” *General Power*:

102. *Every council may pass such by-laws and make such regulations for the health, safety, morality and welfare of the inhabitants of the municipality in matters not specifically provided for by this Act and for governing the conduct of its members as may be deemed expedient and are not contrary to law. 1994, c. 23, s. 54*

*A by-law comes into existence as follows:*⁴

1. *The city council or municipal council makes a decision about a matter within its power, through a simple majority vote by council members. Matters are brought before council through reports and other communications from municipal officials and committees, and they are brought by individual council members. (The council can also delegate bylaw-making powers to others, such as community councils, agencies, and boards.)*
2. *Council’s decision is confirmed by a bylaw enacted at the council meeting. Bylaws are numbered by the year and order of enactment....*
3. *Some decisions of council are then turned over to the city solicitor or municipal solicitor to be drafted into a specific bylaw, particularly if they are decisions that will be frequently referred to, require enforcement, or amend existing bylaws. These draft bylaws are also known as bills. A bill has to be taken back to council for enactment, again through a simple majority vote.*
4. *A bylaw is effective on the date it is enacted unless a different date is specified in the bylaw, in which case it is effective on that date.*

⁴ Margaret Kerr, JoAnn Kurtz & Arlene Blatt, *Legal Research: Step by Step*, Fourth Edition (Toronto: Emond), 28.

Quarry Setback/Buffer Zone Requirements in Various Jurisdictions

Setbacks or buffer zones for blasting quarries vary from 500 metres to 800 metres in the following jurisdictions:

- | | Setback/Buffer Zone |
|-----------------------|----------------------------|
| - Nova Scotia, Canada | : 800 metres ⁵ |
| - New Brunswick | : 600 metres ⁶ |
| - Quebec, Canada | : 600 metres ⁷ |
| - India | : 500 metres ⁸ |
| - Malaysia | : 500 metres ⁹ |
| - Victoria, Australia | : 500 metres ¹⁰ |
- According to the Mine Safety and Health Administration (MSHA), where flyrock incidents have been known to occur at operating surface mines, the “blast area should as a minimum be one-and-a-half times the furthest distance that any previous flyrock has traveled.”¹¹ For example, a known flyrock incident occurring 400 metres from the blast area would require an expanded minimum setback or buffer of 600 metres (400 m × 1.5).
 - On two occasions in July 2009, blasting at the Pakenham quarry near Arnprior launched flyrock beyond the 200-metre control area. In the first incident, a small rock struck a worker at a neighbouring business on the arm. In the second incident,

⁵ “The NSE *Pit and Quarry Guidelines* (1999) stipulated setbacks to prevent structural and environmental damage as well as the requirements for pre-blast surveys, blast monitoring, and blast designs. The setback between blasting for a quarry and structures is 800 m. <http://www.scotianmaterials.info/quarry.html#:~:text=The%20setback%20between%20blasting%20for,800%20m%20of%20the%20Project..>

⁶ “k) 600 metres from any drinking water supply well, unless the written permission of the owner(s) within the 600 metres is obtained and submitted to the Department for acceptance....”, Department of Environment and Local Government, Rock Quarry Siting Standards, <https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Air-Lair/RockQuarrySitingStandards.pdf>.

⁷ “11. The operating site of a new quarry must be located at a minimum distance of 600 m from any dwelling, unless the dwelling is owned or rented to the owner or operator of the quarry.” 10. It is prohibited to establish a new...quarry, the operating site of which is located in a territory zoned by the municipal authorities for residential, commercial or mixed purposes (commercial residential). It is also prohibited to establish a new quarry less than 600 m from such territory...”, <http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/q-2.%20r.%207>.

⁸ “As per Directorate General of Mines Safety circular n. – DGMS (SOMA)/(Tech) Cir. No. 2 of 2003 Dt. 31/01/2003 (Annexure II), on subject of **Dangers due to blasting projectiles**, all places within the radius of **500 m** from the place of firing to be treated as danger zone and accordingly, all person in danger zone to take protection in substantially built shelter at the time of blasting.” “The regulations for danger zone (500 m) prescribed by Directorate of Mines...have to be complied with compulsorily and necessary measures should be taken to minimize the impact on environment.” https://mpcb.gov.in/sites/default/files/whats_new/2020-08/CircularSitingcriteriaforstonequarriesinthestateofMaharashtra03082020.pdf.

⁹ Environmental Requirements: A guide to Investors 2010, Appendix G.

¹⁰ Gill Higgins, “Fair Go: Dust particles from quarry causing adverse health effects for residents nearby,” Inews, June 22, 2020, <https://www.tvnz.co.nz/one-news/new-zealand/fair-go-dust-particles-quarry-causing-adverse-health-effects-residents-nearby>.

¹¹ David Sparkman, “It’s Been a Busy 2018 for MSHA,” ESHToday, Mar 26, 2018, <https://www.ehstoday.com/safety/article/21919560/its-been-a-busy-2018-for-msha>.

rocks were observed flying well beyond the control area. A scale house located 230 metres from the blast was struck by a number of rocks. Two vehicles held at a controlled stop along nearby Young Road on the edge of the quarry property located about 300 metres from the blast were also struck by rock resulting in extensive damage. An investigation of the two off-site flyrock incidents determined that the control zone (setback) should have been 500 metres.¹² (Flyrock 18)

- On two occasions blasting at the Miller Braeside quarry in the Township of McNab/Braeside propelled flyrock debris outside of the limits of the quarry, once in September 2005 and again in August 2007 (Flyrock 22). The 300-metre setback from the quarry boundary proved inadequate, putting neighbouring residents and property at considerable risk. Blasting at the quarry in September 2005 propelled flyrock debris into a nearby residential neighbourhood causing damage to residences, driveways and wells. “One neighbor, Mr. Battison, described flyrock that landed on his roof over 400 metres from the site.”¹³ Reportedly, some neighbours received compensation but only if they signed a confidentiality agreement, and to never come after Miller again for any damages. The August 2007 quarry blast hurled flyrock debris that damaged a home and structurally damaged the foundation of another home in another direction, with one of the property owners (James), claiming \$250,000 in damages.
- City Sand quarry (St. John’s, Newfoundland) carried out a legitimate but inherently dangerous operation, and it had no right to eject flyrock outside the quarry site, which constituted a danger to persons and property. The quarry site was subject to a 300-metre setback. On two separate occasions blasting by City Sand propelled flyrock beyond its property limits, and in one instance the flyrock damaged two houses in a residential subdivision. City Sand’s quarry leases did not confer upon City Sand rights over property outside the quarry site (para. 38).¹⁴ In 1996, in response to a growing awareness of the dangers of flyrock as a public health and safety issue, the Department of Municipal and Provincial Affairs in its conditions for approval of a blasting quarry required a 1,000-metre buffer zone be maintained from a *cottage* or *residence* (Flyrock 42).
- The State of Vermont Environmental Court upheld Moretown Village’s decision not to issue a permit for the proposed Rivers Quarry, based in part on the “unduly harmful” impacts that quarry blasting and potential flyrock hazards would have on

¹² Court Bulletin (Austin Powder Ltd. OCJ 2014), <https://news.ontario.ca/en/court/29428/burlington-firm-fined-130000-for-arnprior-blasting-offences>.

¹³ *Miller Paving Ltd.*, PL130785, OMB, October 27, 2015 [para. 55].

¹⁴ *City Sand and Gravel Limited v. Newfoundland (Municipal and Provincial Affairs)*, 2007 NLCA 51 (CanLII), <<http://canlii.ca/t/1sfnv>>, retrieved on 2020-11-10. Leave to Appeal to the Supreme Court of Canada denied. *City Sand and Gravel Limited and O.D. Holdings Limited v. Her Majesty the Queen in Right of Newfoundland, as represented by The Honourable Minister of Municipal and Provincial Affairs*, 2008 CanLII 1399 (SCC), <<http://canlii.ca/t/1vgkt>>, retrieved on 2020-11-10.

the quality of life of residents residing within 1,500 feet (457 metres) of the quarry:¹⁵

Rivers is recommending that neighbors within 1,500 feet [457 metres] of the quarry suspend their use and enjoyment of their outdoor property whenever a blast is to occur. A dozen times per year, for the next thirty-three years. All of Rivers' neighbors presently enjoy the scenic natural beauty of their property without interruption; some have done so for decades prior to the Rivers quarry being proposed for their neighborhood. The Rivers quarry will bring undue harmful impacts to its neighbors; it fails to conform to criterion 9(E)(i) [impact upon the environment or surrounding land uses]. [p. 63]

Flyrock can travel great distances, as shown by the following incidents reported in the January 1991 issue of Pit & Quarry (p. 44):

• Conklin quarry	(limestone)	:	3,063.6'	(933.8 m)
• Sibley quarry	(limestone)	:	1,159.2'	(353.3 m)
• Roberta quarry	(limestone)	:	4,057.2'	(1,236.6 m)
• Falling springs quarry	(limestone)	:	5,050.8'	(1,539.5 m)
• Okalona quarry	(limestone)	:	4,057.2'	(1,236.6 m)
• Oglesby quarry	(limestone)	:	6,292.8'	(1,918.0 m)
• Latah quarry	(trap rock)	:	828.0'	(252.4 m)
• Mine O	(taconite)	:	11,360.2'	(3,462.6 m)
• Barkely pit	(porphyry)	:	2,119.7'	(646.1 m)
• Mine A	(sandstone)	:	1,987.2'	(605.7 m)

Applying the precautionary principle to proposed blasting quarries, best planning practices warrant locating proposed quarries in locations that:

- do not conflict with existing or proposed incompatible land uses (e.g., residential, commercial, mixed residential-commercial, hotels/motels, schools, places of worship, golf courses, parks, scenic landscapes, historic landmarks, utility corridors, etc.);
- are sufficiently distanced from settlement areas (or proposed settlement areas) and areas of substantial human activity (e.g., heavily travelled roads, highways or trails, convention centres, etc.);
- do not cause social, environmental, human health or safety impacts;
- eliminate the potential for flyrock to damage personal or real property, or to injure or kill people; or
- do not reduce residential property values or homeowner equity, or do not cause residential property to become unmortgageable or unsaleable.

Incidences of Flyrock Unreported or Uninvestigated

Globally, the majority of flyrock incidents go unreported or unnoticed, and in most jurisdictions incidents of flyrock that do not leave the blast area or that do not cause injury or death within or outside the blast area are not officially reported.

¹⁵ *Rivers Dev. Conditional Use Appeal*, <https://cases.justia.com/vermont/environmental-court/2010-03-25-Rivers%20Development%20LLC-1.pdf?ts=1396150941>.

- “Reports of flying rock incidents of stone quarries are a fairly common occurrence, according to Petrie” (Jim Petrie, district manager of the Mining Safety and Health Administration in Warrendale, Pa) (Flyrock 62 – August 22, 2018)
- The accidents due to flyrock are rarely reported (Davies 1995) and is one of the major problems in prediction regime. However, the flyrock that cause no damage are frequent and could be documented for improving prediction models.¹⁶
- Davis (1995) considers under-reporting is responsible for five to ten times the actual number of [flyrock] incidents.¹⁷
- DNX Castonguay Inc. was fined \$75,000 for failing to notify the Ministry of the Environment (MOE) of a May 12, 2010 flyrock incident from a quarry blast in Magnetawan that caused damage to the roof of a garage of an adjacent property.¹⁸ (Flyrock 16)
- On May 28, 2014, a blast at a North Bay quarry launched outside the blasting area onto a neighbouring residential property. The quarry owner, Bruman Construction Inc., and the blaster, Consbec Inc. failed to report the flyrock incident to the Ministry of the Environment and Climate Change (MOECC), and each company was fined \$75,000.¹⁹ (Flyrock 10)
- On September 3, 2014, a blast at a quarry in Merrick Township propelled flyrock onto a neighbouring residential property, and the blasting company Rock Breakers (2007) was fined for failing to report the flyrock incident to the Ministry of the Environment.²⁰(Flyrock 11)
- An April 10, 2018 flyrock incident from a blast at a New South Wales quarry that struck three light vehicles in an exclusion zone remained unreported to the Regulator until September 7, 2018.²¹ After the flyrock incident, those present were asked to delete footage of the blast.²²
- Blasting at a quarry near Arnprior by Austin Powder Limited launched flyrock debris on both July 20 and July 23, 2009 (Flyrock 18), which travelled beyond the 200-metre blast area. In the first incident, a rock struck a worker’s arm at a neighbouring business. In the second incident, rock struck a scale house at a

¹⁶ A. K. Raina, V.M.S.R. Murthy and A. K. Soni, “Flyrock in bench blasting: a comprehensive review,” Bulletin of Engineering Geology and the Environment, © Springer, February 2014, https://www.academia.edu/12477942/Flyrock_in_bench_blasting_a_comprehensive_review_A_Bull_Eng_Geol_Envir.

¹⁷ T.N. Little, “Flyrock Risk,” EXPLOR Conference, Wollongong, NSW, 3-4 September 2007, <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-2570%2120191217T043417.551%20GMT>.

¹⁸ Court Bulletin, <https://news.ontario.ca/en/court/28915/dnx-castonguay-inc-fined-75000-for-failing-to-report-discharge-of-fly-rock>.

¹⁹ <https://www.siskinds.com/failure-notify-brings-150000-fine-despite-no-damage-property/>.

²⁰ Court Bulletin, <https://news.ontario.ca/en/court/35239/drilling-and-blasting-contractor-fined-60000-for-fly-rock-discharge-and-failing-to-report-incident>.

²¹ <https://www.amsj.com.au/flyrock-incident-damages-vehicles-during-blast/>.

²² https://www.resourcesregulator.nsw.gov.au/_data/assets/pdf_file/0003/1248519/Investigation-report-Dangerous-Shotfiring-Incident-Albury-Quarry-10-April-2018.pdf.

distance of 230 metres, and two vehicles held at a control stop on Young Road near the edge of the quarry at a distance of 300 metres were also struck by rocks, causing extensive damage. Austin Powder Limited was fined \$130,000 for failing to report the flyrock incidents forthwith to the Ministry of the Environment.²³

- Blasting of the Niagara Escarpment on August 4, 2004 for the construction of the Red River Valley Expressway propelled flyrock debris the size of softballs 200 metres into a residential neighbourhood that damaged two residences and two vehicles. A prior blast on July 16, 2004 propelled debris that damaged one residence. The blasting company responsible for the flyrock did not report the incidents to the Ministry of the Environment.²⁴ (Flyrock 31)
- On May 17, 2017, a blast at a surface coal mine launched about a dozen lumps of flyrock, where workers were standing, and one 20 kg rock (44 pounds) penetrated the hood of a light vehicle at a distance of 246 metres, inside the 500-metre employee exclusion zone. One worker suggested to the other workers that they should report to the mine that damages to the light vehicle were caused by the car killing a kangaroo while being driven offsite.²⁵ (Flyrock 5)
- Flyrock is less likely to be noticed or reported in sparsely inhabited areas.

According to the Minister of the Environment, in their Factum²⁶ presented before the Supreme Court of Canada in *Castonguay Blasting Ltd. v. Ontario (Environment)*, 2013 SCC 52,²⁷ blasting is as an inherently dangerous activity, which requires all incidents of flyrock to be reported:

²³ Court Bulletin, <https://news.ontario.ca/en/court/29428/burlington-firm-fined-130000-for-arnprior-blasting-offences>.

²⁴ Catch Article: Red Hill blasting nets fine, February 5, 2008, http://www.hamiltoncatch.org/view_article.php?id=247&utm_source=CastonguayNewsletterNov&utm_medium=email&utm_campaign=Castonguay.

²⁵ Investigation Report, "Dangerous shot firing incident at the Moolarben Coal Mine on 17 May 2017, https://www.resourcesregulator.nsw.gov.au/_data/assets/pdf_file/0008/1086677/Investigation-Report-Moolarben-Shot-Firing-Incident.pdf.

²⁶ https://www.scc-csc.ca/WebDocuments-DocumentsWeb/34816/FM020_Respondent_Her-Majesty-the-Queen-in-Right-of-the-Province-of-Ontario-as-Represented-by-the-Minister-of-the-Environment.pdf.

²⁷ *Castonguay Blasting Ltd. v. Ontario (Environment)*, 2013 SCC 52 (CanLII), [2013] 3 SCR 323, <<http://canlii.ca/t/g1038>>, retrieved on 2020-11-14.

Blasting is an inherently dangerous activity with a clear connection to the objective of environmental protection. By its very nature, it destroys or alters the environment for various purposes such as quarrying or construction. The regulation of blasting and the need to report errant blasts is therefore consistent with the broader secondary purposes of the EPA, which include the protection of the environment, people and property from discharges into the natural environment that are likely to cause harm [para. 7]

As reported by Ward,²⁸ the West Virginia Department of Environmental Protection (WVDEP) failed to investigate most of the citizen complaints of flyrock incidents reported to the agency during the period of January 2004 to December 2007. Only 4 of 36 flyrock incidents had been investigated:

...Detailed investigations by WVDEP are performed in few of the flyrock incidents the agency becomes aware of....OSM [Office of Surface Mining] found, OEB was involved in only 4 of 36 flyrock events during the period examined, from January 2004 to December 2007.

OSM recommended that OEB 'should investigate every flyrock event in detail to determine or require the company to determine the most likely cause(s) in order to devise a site-specific remediation plan.

*WVDEP inspectors who cited companies for flyrock incidents **typically ordered the operators to clean up the off-permit [flyrock] material, instead of determining the cause and proposing [sic] corrective measures** to prevent repeat [flyrock] incidents. **During the period examined, the median penalty was [a nominal] \$1,200.***

Flyrock Is Inevitable Wherever Rock Is Blasted

Many explosives experts and authors have commented on the inability to control the throw of flyrock, which is a natural phenomenon whenever explosives are used to blast rock.

- Flyrock can still be generated even in the best-designed blast (Slide 19, Power Point Presentation 2015).²⁹
- Flyrock can never be completely eliminated (Surface mineral workings: control of blasting, 2000).³⁰
- The detrimental effects of flyrock are unavoidable and cannot be completely eliminated... (Ghasemi et al, 2012)³¹
- Flyrock is a hazard that operators try to minimize but is always present (Ormerod, 2019).³²
- Flyrock is an undesirable phenomenon in the blasting operation of open pit mines (Amini, et al, 2011).³³
- Flyrock is a concern for both researchers and blasting engineers as it is a random phenomenon. However, it has received relatively little attention from researchers due to the

²⁸ <http://blogs.wvgazette.com/coalatattoo/2009/08/17/have-a-blast-osm-finds-wvdep-lax-in-policing-flyrock/>.

²⁹ [current developments in quarry blasting - e-library WCL.](#)

³⁰ <https://www.gov.scot/publications/blasting-surface-mineral/>.

³¹ <http://tarjomefa.com/wp-content/uploads/2016/05/4695-English.pdf>.

³² <https://envirosuite.com/news/kaboom-what-happens-around-a-blast-after-it-goes-off>.

³³ [file:///C:/Users/Windows%207%20PC/Downloads/Evaluationofflyrockphenomenonduetoblastingoperati on%20\(1\).pdf](file:///C:/Users/Windows%207%20PC/Downloads/Evaluationofflyrockphenomenonduetoblastingoperati on%20(1).pdf).

complex nature of the interaction between blast design and rock parameters (Raina, et al., 2011)³⁴

- Danger and damage from flyrock in rock blasting has been a serious problem ever since blasting was introduced. Not only have men been killed and injured but also buildings, equipment and materials have been damaged (Lundborg et al. 1975).³⁵
- The phenomena of flyrock are always uncontrolled and can never be brought down to zero (Singh, et al, 2014).³⁶
- Flyrock due to blasting in opencast mines is complex in nature as it is a random phenomenon.³⁷
- “You can never say never.” No matter how careful a blaster is there is no certainty a blast will not cause flyrock. (Tim Rath, Green Mountain Explosives, Testimony at Rivers Quarry Application Hearing)³⁸
- Rivers’ blasting expert cannot guarantee that flyrock will not leave the Rivers parcel, regardless of what precautions are taken to minimize the risk (Cross Exam of Rath 12/15/2008).³⁹
- Every borehole is a separate detonation. This means that during every blast event (at the proposed Rivers’ quarry) there would be 62 chances for flyrock from face burst, cratering, or stemming ejection. After every event, there will be an additional ten seconds or so when flyrock could rain down on neighboring homes, properties and Route 100B that could result in property damages, injury, or even death (Testimony of Art Hendrickson on 12/15/2008, para. 110).⁴⁰
- Flyrock is a potential hazard anytime and anywhere there is blasting (MSHA, 2016).⁴¹
- Blasting is not an exact science (Scott Parker, expert blaster testifying on behalf of Director of Occupational Health and Safety, para. 23).⁴² (Flyrock 20)
- Mining and quarrying are high-risk activities. Misfires and fly rock are common hazards associated with shot firing [blasting] activities, which are routinely undertaken in these industries. (WorkSafe Victoria safety alert published September 7, 2020)⁴³

³⁴ Raina, A.K., Chakraborty, A.K., Choudhury, P.B. *et al.* “Flyrock danger zone demarcation in opencast mines: a risk based approach,” *Bull Eng Geol Environ* **70**, 163–172 (2011). <https://doi.org/10.1007/s10064-010-0298-7>.

³⁵ A. Aghajani-Bazzazi, M. Osanloo and Y. Azimi, “Flyrock prediction by multiple regression analysis in Esfordi phosphate mine of Iran,” © 2010 Taylor & Francis Group, London, <file:///C:/Users/Windows%207%20PC/Downloads/074.pdf>

³⁶ https://www.researchgate.net/profile/Avtar_Raina/publication/264560232_Prediction_of_blast-induced_flyrock_in_Indian_limestone_mines_using_neural_networks/links/5539cf9e0cf247b8588148a8/Prediction-of-blast-induced-flyrock-in-Indian-limestone-mines-using-neural-networks.pdf.

³⁷ R. Trevidi, T.N. Singh and A.K. Raina, “Prediction of blast-induced flyrock in Indian limestone mines using neural networks,” *Journal of Rock Mechanics and Geotechnical Engineering* **6** (2014) 447-454.

³⁸ <http://www.killthealbionquarry.org/DEATH-FROM-THE-SKY-FLYROCK.html>.

³⁹ http://www.killthealbionquarry.org/flyrock_danger.pdf.

⁴⁰ “Blasting and Flyrock,” http://www.killthealbionquarry.org/flyrock_danger.pdf.

⁴¹ <https://www.msha.gov/news-media/announcements/2016/03/24/flyrock-dangers-best-practices>.

⁴² *Director of Occupational Health and Safety v. Government of Yukon, William R. Cratty and P.S. Sidhu Trucking Ltd.*, 2012 YKSC 47 (CanLII), <<http://canlii.ca/t/fs6vt>>, retrieved on 2020-11-16. “The whole purpose of the OHS Act is to promote safe practices in the workplace at all time. This includes safety for members of the public that are in proximity to the workplace [para. 46].”

⁴³ <https://www.aggregeresearch.com/news/state-investigates-quarry-blast/>.

- Flyrock meets the Ontario EPA definition of contaminant, and the adverse effects of “flyrock” are not trivial (Castonguay Blasting Ltd. v. Ontario (Environment), [2013] 3 SCR 323, 2013 SCC 52 (CanLII)).
- According to Section 21.66 (1) of the Occupational Health and Safety Act (OSH), B.C., a blaster must take precautions against *flyrock*, which is referenced as “flying” material.⁴⁴
- In April 2015, WorkSafeB.C. suspended the blaster’s permit after a flyrock incident rained rocks on a Colwood Neighbourhood, including a 17-pound rock that smashed through a couple’s bedroom ceiling and broke their bed frame.⁴⁵ (The company doing the blasting for Colwood’s Allandale Pit received three penalties from WorkSafeB.C. within three years for violations related to flyrock.)

According to Lundborg, people should never be exposed to flyrock. Similarly, national laws in Chile relating to workplace safety require that workers never be exposed to flyrock. This requires that the probability of flyrock be zero for personnel (and non-personnel) located outside the Personnel Clearance Distance (blast area) for all blasts.⁴⁶ Likewise, Kentucky’s Energy and Environment, Department for Natural Resources, has expressed a zero tolerance for flyrock incidents:⁴⁷

The Department for Natural Resources believes that one flyrock event is too many, and to that end, has prepared this RAM [Reclamation Advisory Memorandum] to further define steps this Department will require of the coal industry in eliminating flyrock events.

‘Flyrock’ is defined as ‘blasted material cast into the air, or traveling along the ground, that is cast from the blasting site more than half the distance to the nearest dwelling, public building, school, church, commercial, community or institutional building; or any occupied structure; or that is cast beyond the permit boundary.’

Flyrock events historically have not been limited to blasting operations within the distances which require the submission and approval of an ‘anticipated blast design’...prior to blasting. Rather, flyrock events occurred and impacted dwellings, vehicles, persons, animal life, and other physical structures thousands of feet from the blast site resulting in death and the destruction of property.

In response to a spike in flyrock incidents, the Queensland Government issued a safety bulletin in February 2009,⁴⁸ which, in part, states:

In the past few months, there have been some very serious incidents reported from the coal mines of the Bowen Basin, North Queensland and from quarries around Brisbane. All of these could well

⁴⁴ <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-21-blasting-operations#SectionNumber:21.66>.

⁴⁵ Kyle Esser, “Blaster has permit suspended after rain of rocks in Colwood,” Times Colonist, April 16, 2015, <https://www.timescolonist.com/news/local/blaster-has-permit-suspended-after-rain-of-rocks-in-colwood-1.1825157>.

⁴⁶ “Flyrock – A Basis For Determining Personnel Clearance Distance And Quantifying Risk of Damage to Equipment,” scribd.com.

⁴⁷ “Reclamation Advisory Memorandum,” <https://eec.ky.gov/Natural-Resources/Mining/Mine-Permits/RAMS/RAM140.pdf>. “During calendar year 2007, the Commonwealth of Kentucky had a [known] total of thirteen (13) flyrock events on surface coal mining sites, include one (1) that resulted in a fatality. To date [July 18] there have been nine (9) [known] flyrock events, including one (1) that resulted in a minor injury that very easily could have resulted in a fatality.”

⁴⁸ “Flyrock Incidents,” <https://www.dnrme.qld.gov.au/business/mining/safety-and-health/alerts-and-bulletins/explosives/flyrock-incidents2>.

have ended up with very serious or fatal results. Significant damage to property and structures has also been reported. The frequency of these incidents has reached a point where it is well beyond acceptable limits.

Flyrock is an integral part of blasting. However, uncontrolled or unexpected flyrock that is projected past a defined safety zone is not acceptable. It is well known that rock and/or debris can be thrown over a kilometre from the blast site, and in a recent case rocks travelled approx 1.3km [1,300 metres].

Why Is Flyrock So Dangerous?

Most people have never heard of *flyrock*, and yet it is the most dangerous aspect of blasting rock. Wherever there is blasting of rock, flyrock can occur, and, no matter how well a blast is executed, the consequences of flyrock are unpredictable. Flyrock can launch in any direction at great speed, and flyrock debris can shower a large area. Flyrock comes in all shapes, sizes and weights. Flyrock has the potential to damage the environment and personal and real property, and injure and kill people, livestock and wildlife. Flyrock is any material propelled from a rock blasting operation.

The following extracts address flyrock, and are from a 2019 Worker's Hazard Alert issued by the National Institute for Occupational Safety and Health (NIOSH):⁴⁹

Why do you need to read this? Flyrock has killed and injured people. *Flying material, both within the blast area and outside it, is responsible for over half of all blasting –related injuries and fatalities. MSHA (Mine Safety and Health Administration) records from 1994-2001 show that in surface mining, 32 people were killed or badly hurt because the blast area was not cleared. Another 17 people were injured or killed by rocks that were thrown outside of the blast area. This total (49 people) is greater than the combined total of the other blast accident causes in mining (premature blast, transporting explosives, fumes, and misfires). Flyrock is a potential hazard anytime and anywhere there is blasting [p. 1].*

...Blasting is the best way to shatter rock. In a blast, a number of holes are drilled into the ground and loaded with explosives. The BLASTER-IN-CHARGE computes the ideal distance between these holes, the depth of the holes, and their slant or angle....

Flyrock can be as small as marbles or as large as a car. It is propelled with great force. Flyrock may come from high in the air, roll down a hillside, or come straight at you like a bullet. That is why the blaster places guards at entry roads around the area where rocks might fly—to keep people out and protect workers from death and injury. Yet people have still been killed inside [and outside] the blast area...[p. 7].

What is the danger from flyrock? *Flyrock can come at you from any direction. Flyrock can be thrown high like a fly ball, fly straight like a fastball, roll along the ground, or ricochet from any direction. Flyrock can be gravel, rocks, tree trunks, construction materials, mud—even water [p. 3]....*

What causes flyrock? *Sometimes problems occur during blasting. There may be a hidden crack below ground that the blaster fills with too much explosive. The blaster may think that he or she has to break a lot of tough granite, when really there is soft dirt from old diggings. The blast crew may have made a mistake and not loaded enough stemming. A mud seam below ground may not have been reported by the driller. These things seldom happen. But when they do, there is going to be flyrock—debris that travels beyond the guarded area...[p. 7].*

Flyrock is totally unexpected. *"I had shot a dozen of these. Each of them went 'poof.' The ground rose up and fell down. Just 'poof.' One of the regulars was standing by his door, just inside the blast*

⁴⁹ <https://www.cfans.com/wp-content/uploads/2019/01/blasting-safety-worker-alert.pdf>.

area. I told him he had to go inside. He said, 'don't worry, nothing will happen.' I said, 'I know that, but you will have to go inside anyhow.' He fussed and we discussed, but in the end he went inside. We shot it, and it blew all over the place. There had been a water line there beside the hole, must have been decades ago. So the earth was not the hard rock that we expected. And it blew. Rocks landed right beside the door where the man had been standing. Had he stayed there, he would have been hurt.' –J.E., a Kentucky blaster [p. 3].

Flyrock is fast. On a Friday evening in 1994, two blast crew members were 236 feet away from the blast. The crew saw the flyrock coming toward them as soon as they set off the shot. They turned and ran to a pickup truck that was just 10 feet away. They did not make it. The survivor heard the flyrock hit the pickup truck and the ground. Then he saw his partner beside the pickup truck lying face down with blood coming out of his nose and ear. His hardhat was dented by the flyrock. He never regained consciousness [p. 3].

Flyrock can travel beyond the blast area. It can travel far and high. In July 2002 in West Virginia, rocks traveled one-half mile. One rock the size of a football smashed into the cab of a contractor's truck. It went through the front windshield, between a trucker and his supervisor and out the back. They were outside the blast area thought they were "safely" watching. They were lucky—they were not hurt [p. 5].

Additional concerns around the use of explosives to blast rock and the undesirable and potentially dangerous generation of flyrock are as follows:

Despite the fact that flyrock uses only about one percent of the explosive energy caused by the blast, it is responsible for up to 40 percent of injuries, as opposed to, for example, ground vibration. One can easily understand this when we think of flyrock as small projectiles fired with great force by exploding gasses. Essentially, the effect of flyrock is similar to spraying an area with bullets from a machine gun.

Complicating matters is the fact that separating pieces of rock from a rock face is the goal of blasting, whether it is actually to get at the minerals within the rock face or to get at what is behind it. Thus, blasters have every intention of creating this [flyrock] debris. However, the goal is to do it with controlled throw – knowing exactly where the pieces are going to go and making sure not to be in range of them.

Unfortunately, predicting the trajectory and amount of flyrock has proven to be a very inexact science. While steps can be taken to minimize flyrock and one can generate some reasonable predictions about rock throw, there are too many random elements to predict the trajectory, range and size of all explosive debris accurately.

This creates a massive problem for project managers because it is so crucial that they get these calculations right. Underestimating flyrock predictions can put people's lives and the company's property in danger while overestimating can impede the progress of the project. Studies to try to more accurately predict the impact of flyrock in various blasting situations have proven costly and not yielded highly satisfactory results.

While it is not currently possible to prevent the creation of flyrock itself, almost all flyrock injuries and fatalities, as well as flyrock damage to property, is avoidable when taking the proper precautions. Too often, people on mining or construction sites fail to anticipate the problems flyrock will cause, or they think of it as 'a necessary evil' and hope for the best.

This kind of thinking can only lead to tragedy. Then there is the fact that some industries and situations that are not mining or construction related can also be prone to an unanticipated explosion, and the people in those situations often have no preparation or protection against flyrock whatsoever. Clearly, this is a problem people need to address.⁵⁰

⁵⁰ "Preventing and Controlling Flyrock," <https://www.tmi2001.com/blog/preventing-controlling-flyrock/>.

DEP Chief Regulator Informs Explosives Engineers of Dangers of Flyrock

A letter from the PA Regulator (Chief, Explosives & Safety, Department of Environmental Protection (DEP), Bureau of Mining Programs), addressed to the Eastern Pennsylvania Chapter of the International Society of Explosives Engineers (ISEE), describes the dangers of flyrock and acknowledges that blasting is an ultrahazardous activity. **That is quite an admission! It does beg the question: why would the Regulator have to inform the ISEE about the dangers of flyrock and that blasting is an ultrahazardous activity? Is it possible that members of the ISEE do not understand the dangers inherent in blasting or do ISEE members simply choose to ignore or bypass the issue of flyrock when preparing Blasting Impact Analysis/Assessment reports on behalf of the aggregate industry?** The Regulator's letter was posted July 27, 2020, on the ISEE Chapter website:⁵¹

Flyrock is an inherent risk of blasting, but is preventable. It does not have to happen. When it does occur there is a lot of effort by the blasting contractor, the permittee and DEP to find out why it happened and how to prevent it from happening again. Current blast records and widespread videotaping of blasts are critical for these efforts to succeed. These days most flyrock incidents are not caused by basic blast design errors such as too little stemming, boreholes too large for hole depths or burdens and spacings being too large or small. Most of the flyrock incidents that have occurred recently have been due to precautions not being taken to address conditions in the rock being blasted.

Quarry faces are often uneven which requires bore tracking and face profiling. Careful drilling with appropriate drilling equipment for the site conditions are a must as are detailed drill logs, so the blaster is aware of any changes in the rock. On construction blasting operations one of the biggest problems is inconsistent rock. Care must be taken to ensure that the blaster knows the extent and condition of the rock surrounding each and every borehole.

Blasting is an ultrahazardous activity and is regulated as such. Flyrock is prohibited. Flyrock is a serious violation and appropriate enforcement action will be taken in each case. All blasting in PA must be authorized by DEP permits. The activities conducted on those permits should not be a danger to the public or their property.

When designing blasts please be careful to include any measures that will prevent flyrock. We have been very fortunate to not have a flyrock fatality in PA since 1999. However, there have been several incidents in the past few years where there was potential for injury or worse. Added precautions will help to ensure flyrock incidents do not occur.

Flyrock Statistics Cited by Different Sources

As acknowledged by Raina *et al.* in their February 2015 article,⁵² "flyrock is one of the most contentious issues in bench blasting [and] has the propensity to cause fatality and severe injuries." Flyrock, arising from open-pit blasting, continues to elude explosives engineers, despite a reasonable understanding of throw [p. 660]. According to the article, the amount

⁵¹ <https://www.easternpaisee.com/letter-from-the-chief-on-flyrock/>.

⁵² Raina, A. K., Murthy, V. M. S. R. and Soni, A. K., "Flyrock in surface mine blasting: understanding the basics to develop predictive regime," Current Science, Vol. 108, No. 4, 25 February 2015, <https://www.currentscience.ac.in/Volumes/108/04/0660.pdf>.

of research conducted on flyrock is “abysmal,”⁵³ and the percentage of accidents occurring due to flyrock justifies its importance irrespective of the fact that the problem is seldom reported.⁵⁴ Over various timeframes, the percentage of injuries attributed to *reported* flyrock incidents by the following authors ranges from 19.05% (Verakis and Lobb)⁵⁵ to 68.20% (Little)⁵⁶:

Table 2. Accident statistics of reported flyrock cited by different authors

Reference	Period	Blasting injuries	Percentage of flyrock injuries in blasting related accidents
Mishra and Mallick ¹¹	1996–2011	30	24.19
Verakis ¹⁰	2010–2011	18	38.00
Bajpayee <i>et al.</i> ⁹	1978–1998	281	40.57
Verakis and Lobb ¹⁹	1994–2005	168	19.05
Little ²⁰	1978–1998	412	68.20
Kecojevic and Radomsky ²¹	1978–2001	195	27.69
Adhikari ²²	–	–	20.00

- According to Dyno Nobel Americas, which participated in a 2008 “Blast Service Management” presentation, in one year they fire “approximately 100 blasts per day” and reports “approximately 150 [customer] flyrock incidents annually,” while conceding that “many [flyrock] incidents aren’t reported.” In 2007, Dyno Nobel Americas had 32 flyrock incidents for 30,021 quarry blasts or 1.07 flyrock incidents per 1,000 blasts.⁵⁷
- During 2019, the Tennessee State Fire Marshal’s Office received 302 blasting complaints, of which 14 were for *flyrock*, accounting for 5% of the blasting complaints.⁵⁸
- Canada does not track the number of flyrock incidents that have led to death or injury caused by blasting at surface mining operations. However, according to the National Institute for Occupational Safety and Health (NIOSH), flyrock at surface

⁵³ Raina, A. K., Soni, A. K. and Murthy, V. M. S. R., “*Spatial distribution of flyrock using EDA: An insight from concrete model tests.* In *Rock Fragmentation by Blasting* (eds Singh, P. K. and Sinha, A.),” Taylor and Francis, London, 2013, pp. 563–570.

⁵⁴ Davies, P. A., “*Risk based approach to setting of flyrock danger zones for blasting sites,*” *Trans. Inst. Mines Met.*, May–August 1995, 96–100.

⁵⁵ Verakis, H. and Lobb, T., “*Flyrock revisited an ever present danger in mine blasting,*” 2007; <http://docs.isee.org/ISEE/Support/Proceed/General/07GENV1/07v109g.pdf>.

⁵⁶ Little, T. N., “*Flyrock risk*”. In Proceedings of EXPLOR Conference, Wollongong, NSW, 3–4 September 2007, pp. 35–43, <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-2570%2120191217T043417.551%20GMT>.

⁵⁷ “Blast Service Management, <https://www.911metallurgist.com/blog/wp-content/uploads/2016/01/Blast-Service-Management.pdf>.

⁵⁸ 2019 Annual Report on Blasting Fines in Tennessee, https://www.tn.gov/content/dam/tn/commerce/documents/fire_prevention/posts/2019-BLASTING-COMMISSIONERS-REPORT.pdf.

mining operations in the United States has killed or injured 311 people from 1978 to 2004.⁵⁹ NIOSH defines flyrock as,

“any debris that lands outside the designated blasting area. It can vary in mass from marble-sized to car-sized and can be incredibly dangerous and potentially fatal.”

Examples of Flyrock’s Greatest Hits!

Some of the more disturbing and fatal flyrock incidents, compiled from a variety of sources, are listed as follows:

- A quarry blast launched an 82-pound boulder 402 metres that penetrated the roof of the porch of David Ross’s residence and tore off the home’s siding (Flyrock 58 – August 23, 2010).
- A large amount of flyrock travelled approximately 300 feet (91 metres) and struck a car on Interstate 75, and a 16-year old boy, a passenger in the car driven by his parents, was killed as a result of the flyrock impact (Flyrock 34 – June 4, 1993).⁶⁰
- Flyrock fragments travelled approximately 483 metres striking and killing 40-year old Bobby Messer, a mechanic, and rocks hit and damaged the mechanic’s truck (Flyrock 74 – July 16, 2007).
- Two employees were injured and a third employee had her arm severed below the elbow after being struck by baseball-sized rocks propelled 400 metres to 500 metres from the quarry blast (Flyrock 13 – September 26, 2011).
- A quarry blast launched flyrock debris into a residential neighbourhood that struck and damaged five properties (Flyrock 55 – November 27, 2019).
- A quarry blast launched flyrock debris more than 300 metres and caused widespread damage to the quarry plant, private cars and buildings within the complex, and three people were injured (Flyrock 49 – January 10, 2006).
- A quarry blast showered flyrock debris over an area of 650 metres that struck and damaged three residences, primary school, tavern, saw mill and fish pond (Flyrock 61 – May 5, 2007). **The forensic investigation of this catastrophic flyrock incident “led to the conclusion that it was necessary to set the safe distance for residents at [a] distance [greater] than 700 metres.”** [emphasis added]
- A quarry blast launched boulder fragments that struck and killed 10-year old M. Nandhini, and that struck and injured her brother Soundarrajan (Flyrock 68 – May 27, 2020).
- A quarry blast hurled hundreds of rocks, some the size of car tires, which sprayed a shopping centre, office complex and service station, and injured three people, one of them critically (Flyrock 64 – February 4, 2009). Police closed off roads littered with large chunks of rocks, and paramedics and emergency workers raced to treat the injured.

⁵⁹ Josh Cabel, “NIOSH Offers Tips for Flyrock Safety,” EHSToday, January 25, 2007, <https://www.ehstoday.com/construction/article/21911356/niosh-offers-tips-for-flyrock-safety>.

⁶⁰ The United States District Court for the Eastern District of Tennessee sentenced the blaster to 10 months, five to be served in a penitentiary and five months to be served under home detention (with electronic monitoring) followed by a year of supervised probation.” The day shift superintendent was given an eight-month sentence. The company went out of business within four months of the blasting incident.

- A quarry blast launched flyrock debris, some of which bore through the roof of a house and struck and killed 36-year old Shupikai Chitsana, and her aunt was also struck by flyrock, but she survived her injuries (Flyrock 41 – August 15, 2019). Shupikai leaves behind her five children and husband.
- A quarry blast showered flyrock debris as far as 1,000 metres that damaged 18 cars and 14 factories, and injured 10 factory workers and killed one factory worker in a factory penetrated by numerous rocks at a distance of 500 metres (Flyrock 12 – July 19, 2013). A team of 37 fire and rescue personnel carried out a search and rescue operation with the assistance of 16 policemen and TNB employees before declaring the area safe for the public.⁶¹
- A quarry blast showered flyrock debris that damaged 14 pieces of parked equipment and several vehicles, injuring one person, and a 309-pound boulder was launched 250 metres (Flyrock 46 – 2008).
- A quarry blast showered flyrock debris 3,000' (914 metres) on an industrial park doing damage to a building and 11 vehicles in the Technica USA parking lot, and flyrock debris was showered 4,000' (1,219 metres) in another direction landing on a runway of West Lebanon Airport (Flyrock 24 – June 11, 2007).
- A quarry blast launched 13 boulders across a four-lane highway into resident's yards of 5-acre estate lots, and a store. A car was damaged, and another 50-pound boulder was launched 1,760' (520 metres) (Flyrock 26 – April 25, 2006).⁶²
- A quarry blast generated excessive airblast (145 decibels) and flyrock debris that damaged 23 homes. Three homes had structural damage from flyrock and two homes had glass broken from their windows (Flyrock 37 – November 3, 1989).

Examples of Known Repeat Flyrock Offenders

The following are examples of blasting operations where the incidence of flyrock has occurred on more than one occasion.

- Gateway Materials Quarry (2 known flyrock incidents – Flyrock 7 & 29)
- Alum Luck Mine (2 known flyrock incidents – Flyrock 17)
- Arnprior Quarry (2 known flyrock incidents – Flyrock 18)
- Hamilton Boulevard Extension (2 known flyrock incidents – Flyrock 20)⁶³
- Percy Quarry (2 known flyrock incidents – Flyrock 21)
- Miller Braeside Quarry (2 known flyrock incidents – Flyrock 22)

⁶¹ Edy Tonnizam Mohamad, Danail Javed and Hossein Motaghedi, "The Effect of Geological Structure and Powder Factor in Flyrock Accident, Masai, Johor, Malaysia," EJGE, Vol. 18 [2013], Bund. X: 5661-5672, <http://www.ejge.com/2013/Ppr2013.485mar.pdf>.

⁶² "Denny Perry, president of Stuart M. Perry Quarry, said his family's business contracts Winchester Building Supply to do all their blasting. 'We got out of it because we felt it was safer and more economic,' he said. 'We didn't want to store explosives.'" <https://www.aggregeresearch.com/news/state-investigates-quarry-blast/>.

⁶³ November 1, 2007, a piece of flyrock flew 350 metres penetrating the roof of a residence and landing in the living room (para. 7) in the Lobird Trailer Court neighbourhood. On May 6, 2008 flyrock debris was launched onto the same neighbourhood penetrating the roof of one residence and landing in the living room, and showering flyrock debris struck roads, fences, sheds and residences (trailers) (para. 1). *Director of Occupational Health and Safety v. Government of Yukon, William R. Cratty and P.S. Sidhu Trucking Ltd.*, 2012 YKSC 47 (CanLII), <<http://canlii.ca/t/fs6vt>>, retrieved on 2020-11-16.

- Comsbec Red Hill Valley Parkway (2 known flyrock incidents – Flyrock 31)
- Surface Mine Campbell County (2 known flyrock incidents – Flyrock 34)⁶⁴
- City Sand’s Quarry (2 known flyrock incidents – Flyrock 42)
- Hobet Mine (2 known flyrock incidents – Flyrock 45)
- Netley Branch Mine (numerous flyrock incidents over 15 years – Flyrock 51)
- Imperial Quarry (2 known flyrock incidents – Flyrock 65)
- Morrisville Mine (2 known flyrock incidents – Flyrock 66)
- Manitou Sand and Gravel Pit (2 known flyrock incidents – Flyrock 75)
- Colwood’s Allandale Pit (3 known flyrock incidents)⁶⁵
- Trail Bay Estates (2 known flyrock incidents)⁶⁶

Empirical Methods of Calculating Flyrock Phenomenon Not Accurate

There are several empirical methods for calculating *flyrock*, but none are capable of accurate prediction due to the complexity of flyrock analysis.

Only a fracture of the accessible explosive energy is practically employed in rock fragmentation, and the rest of the energy is wasted in the form of unwanted events such as fly rocks, back breaks, etc. [1, 2]. Although safety has favorably been enhanced in the mining blasting operation, but various accidents due to flyrock phenomenon have been reported by the Mine Safety and Health Administration (MSHA) [3–6]. According to Institute of Makers of Explosives (IME), flyrock is defined as the rock propelled beyond the blast area by the force of an explosion [7]. Many experimental and theoretical researches on flyrock phenomenon have demonstrated that insufficient delay timing between blast rows, stemming and burden, geological discontinuities, excessive charge, and deviation in drilling process is the main reasons of flyrock occurrence [8–11]. The researches by Ladegaard-Pedersen and Holmberg [12] revealed the relationships between powder factor, density of the explosive and flyrock. Lundborg [13] studied the blasting operations in granite and proposed a prediction model for flyrock in hard rock. Also Bajpayee et al. [14] and Raina et al. [15] have proposed empirical prediction models for flyrock. These models have focused on the prediction of the initial velocity and maximum distance of the fragmented rocks from the blasting face.

Despite considerable efforts, [the] difficult nature of rock engineering problems has caused previously empirical methods to be not appropriate in predicting flyrock phenomenon. Most of these models have been developed based on blasthole diameter.

Despite the considerable progress made over the last three decades, significant challenges for wholly omitting of unwanted flyrock phenomenon, injuries, and fatalities still exist.⁶⁷

⁶⁴ <https://www.osmre.gov/resources/blasting/docs/Flyrock/1993SugarRidgeFatality.pdf>.

⁶⁵ Shalu Mehta, “Three penalties in three years for blasting firm working Allandale lands in Colwood,” Jan. 9, 2020, <https://www.saanichnews.com/news/three-penalties-in-three-years-for-blasting-firm-working-allandale-lands-in-colwood/>.

⁶⁶ Christine Wood, “Residents raise concerns with blasting,” CoastReporter, April 6, 2007, <https://www.coastreporter.net/news/local-news/residents-raise-concerns-with-blasting-1.1179765>.

⁶⁷ Hasel Amini, Raof Gholami, Masoud Monjezi, Seyed Rahman Torabi and Jamal Zadhesh, “Evaluation of flyrock phenomenon due to blasting operation by support vector machine,” *Neural Computing & Applications*, May 2011, <file:///C:/Users/Windows%207%20PC/Documents/Evaluation%20of%20flyrock%20phenomenon%20due%20to%20blasting%20operation%202011%20Amini%20et%20al.pdf>.

Blasting Standards Inadequate to Avoid Structural Damage to Nearby Residences and Blast Vibration Complaints

In case studies⁶⁸ of two residences near subsurface blasting excavations the houses experienced damage, and it was concluded that the damage was the result of the *structural* response to the ground vibrations:⁶⁹

Subsurface construction blasting generates ground vibration which may have a damaging effect on residential buildings. Codes of practice define damage criteria to limit the effect of the vibrations resulting from the subsurface blasting on nearby structures. All these criteria are based on the soil Peak Particle Velocity (PPV) generated due to blasting on the ground surface close to the structure. The real culprit, however, is not the ground PPV but it is the structural response to the ground vibration....

Blasting is generally adopted for rock excavation; the level of the resulting ground vibration and the structural response depends on the explosive type and weight, delay time, blasting technology, soil properties, distance between the structure and the blasting centre, susceptibility ratings of the adjacent and remote structures, and the age and type of the structure [ST-051-1]....

When a charge is detonated in a solid medium (like rock), a family of waves is generated. These waves generate different particle movement and travel at different wave velocities. The resulting ground-borne vibrations may have an effect on residential buildings ranging from disturbing the occupants to causing severe threshold “cosmetic” or structural damage. Problems may occur as a result of large amplitude (low frequency) vibrations, repeated occurrence of smaller amplitude vibrations, or from differential settlement induced by soil particles rearrangement. Classifying ground vibrations types, monitoring their effects and establishing their severity were widely investigated (Dowding 1985; Franfield 1996; Dowding; 1996; Massarsch 1993; Wiss 1981; Skip 1984) [ST-051-1].

Ground vibrations resulting from subsurface construction blasting are usually monitored to assess their impact on nearby structures. Currently, there are no unified or widely accepted criteria for the safe limits of ground vibrations (Svinkin 2004). Codes of practice adopt safe limit criteria which are mainly based on field observation (ISEE 1998). Most of these criteria correlate the structural damage with the soil Peak Particle Velocity (PPV) produced on the ground surface close to the structure. Some other criteria correlate the structural damage to the PPV together with the soil particles vibration’s frequency. Most of the safe limit criteria limit the PPV of the ground vibration to 51 mm/s at the nearest “non-owned” structure to the blasting site. However, it is not the soil PPV that matter but it is the structural response to the ground vibration: all the blast-vibration complaints are actually due to the structure vibration not the ground vibration. Thus, the currently adopted criteria can not define reliable and acceptable safe limits for subsurface construction blasting. Three factors of ground vibration affect the structural response: ground vibration amplitude defined via the PPV, ground vibration duration (which is not the same as the blast duration), and ground vibration frequency. Usually seismographs report the PPV and the frequency and often ignore the duration. Reducing ground vibration duration would reduce the structure response but increase the perception of the occupants to the ground vibration {ST-051-1}....

Currently, there is no universally accepted standard for safe limit of ground vibrations generated by blasting. However, the International Standards ISO 4866-1990 refers some major regulations of

⁶⁸ E. Y. Sayed-Ahmed and K. K. Naji, “Residential Houses Cracking Due to Nearby Subsurface Construction Blasting: Critical Review of Current Safe Limits,” Civil Engineering Department, University of Qatar, Doha, Qatar, paper presented at 1st Int’l Structural Specialty Conference, Calgary, Alberta, Canada, May 23-26, 2006, https://www.researchgate.net/publication/280530625_Residential_Houses_Cracking_Due_to_Nearby_Subsurface_Construction_Blasting_Critical_Review_of_Current_Safe_Limits#:~:text=Subsurface%20construction%20blasting%20generates%20ground,damaging%20effect%20on%20residential%20buildings.&text=All%20these%20criteria%20are%20based,surface%20close%20to%20the%20structure.

⁶⁹ Ground vibrations can be caused by construction, equipment or blasting, etc.

ground vibrations for different types of buildings. It was continuously argued that the structural/threshold damage could be related to the PPV of the ground vibration (Duvall and Fogelgon 1962; Wiss 1968; ISEE 1998) [ST-051-2]....

The [German] DIN 4150 and the Swiss Standards criteria for safe limits against ground vibrations resulting from blasting are...plotted in Figure 2 and compared to the criterion of the US OSM. It is evident from Figure 2 that these two criteria are significantly conservative compared to both the American and British criteria. It was argued that the DIN 4150 criterion is not damage-based; it is intended to minimize the perceptions and complaints of housing residents who live adjacent to blasting sites [ST-051-04]....

Despite its wide applicability, the currently used safe-limit criteria for ground vibration which are all based on the PPV and frequency of the ground vibrations fail in many situations (ISEE 1998; Quesne 2001). For example, these criteria make no distinction for the type, age or stress history of the structure; all of which considerably affect the safe limits [ST-051-4].

A major drawback is also in the concept of the safe limit criteria itself. The currently adopted criteria were obtained by only correlating the structural damage to the intensity of the ground vibration. However, a safe limit criterion against ground-born vibrations due to blasting should be based on the structure vibration/response not the ground vibration. In other words, the 51 mm/s safe-level criterion should be applied to the PPV of the structural vibration due to blasting not to the soil vibration [ST-051-4].

The intensity of the vibration depends on the soil-structure interaction that determines the structure responses to the ground excitation. A ground vibration frequency which is 40% (or more) greater than the fundamental frequency of the structure introduces a structure PPV that is less than the PPV of the ground vibration. On the other hand, a ground vibration with a frequency below the fundamental frequency of the structure causes the structure to vibrate at least as much as the ground. If the ground vibration frequency is close to the structural natural frequency, a state of resonance may be generated and the PPV of the structure will increase considerably beyond the PPV of the ground vibration. This phenomenon is totally disregarded in all the currently adopted safe limit criteria against ground-born vibrations due to subsurface blasting [ST-051-4].

Low-rise buildings have a natural frequency in the order of 4~12 Hz (Medearis 1977; Siskind 1980; ISEE 1998). However, the structures and their parts (e.g. floor, walls, etc.) respond differently to ground vibration as they have different natural frequencies. For example, the natural frequencies are 12~20 Hz for interior walls' horizontal vibrations and 8~30 Hz for floors vertical vibrations. Mid-walls' vibrations cause residential buildings to "rattle" making vibration more noticeable and aggravate human response to annoyance from ground vibration. It is difficult, if not impossible, to follow a uniform vibration standard to reduce the human perception of vibration due to subsurface blasting (Baliktis 2001) [ST-051-5]....

Data recorded for the two case studies of houses located nearby subsurface blasting were examined. It is evident from the readings of the seismographs (samples of them are summarized in Tables 2 and 3) that the PPVs recorded for all blasting events were well below 51 mm/s; the safe limit required by the Mol [Ministry of Interior] and defined in most of the currently available safe limit criteria [ST-051-8].

...[P]lotting the relations between the PPVs and the frequencies of the ground vibrations for these events (Figures 5 and 7) reveals that the ground vibrations satisfy the safe limit criteria set by the USBM, the OSM and the BS 7385. Some the events do not satisfy the Swiss Standards and most of them are unsafe compared to the DIN 4150 specifications. However, these two standards are human annoyance driven as opposed to structural damage driven criteria [ST-051-8].

Despite satisfying all these criteria, threshold cracks, and even structural cracks, appeared in these [two] houses after the excavation by blasting. Furthermore, the residents complained that the blasting effects were significantly pronounced [ST-051-8].

The authors of the two case studies recommend that the PPV for low level frequencies (4-30 Hz) be multiplied by 4 before comparing them to the current safe limits, with the value of the factor refined to include the ratio between the ground vibration frequency and the natural frequency of the nearby structure, while conceding this concept still needs to be explicitly experimentally verified.

In a subsequent paper published in 2013 by the same authors (Sayed-Ahmed and Naji),⁷⁰ they reiterate their findings of cracks and structural damage to two nearby houses caused by blasting, even though the blasting had been carried out within regulatory limits, and recommend application of a safety factor. The authors also allude to a 2005 study by Gad et al, which confirms their findings, and they too suggest application of a safety factor.

Rock excavation is commonly adopted by blasting which generates a family of waves that travel at different wave velocities. Approximately 15% of the total blast energy is utilized for actual breakage and mass displacement with the reminder spent on undesirable activities Niclson (2005). Among these are the ground-borne vibrations which may have an effect on residential buildings ranging from disturbing the occupants to causing severe threshold “cosmetic” or structural damage. Problems may occur as a result of large amplitude (low frequency) vibrations, repeated occurrence of smaller amplitude vibrations, or from differential settlement induced by soil particles rearrangement. Classifying ground vibrations types, monitoring their effects and establishing their severity were investigated (Dowding1985; Franfield 1996; Dowding 1996; Massarsch 1993; Wiss 1981; Skip 1984). The level of ground vibration resulting from subsurface blasting and the structural response depends on the explosive type and weight, delay time, blasting technology, soil properties, distance between the structure and the blasting centre, susceptibility ratings of the adjacent and remote structures, and the age and type of the structure [p. 93].

This paper shows that it is not the soil PPV that matter but it is the structural response to the ground vibration: all the blast-vibration complaints are actually due to the structure vibration not the ground vibration. Thus, the currently adopted criteria cannot define reliable and acceptable safe limits for subsurface construction blasting [p. 94].

It is evident that the currently adopted safe limit criteria ignore a very important factor which is the structural response to the ground vibration. It is argued that ground vibrations with low level frequencies affected the structural response of these two houses causing resonance and wall rattling. These, in turn, caused threshold, and even structural, cracks beside the severe disturbance to the residents [p. 97].

So, as a modification, the PPVs of the low level frequency vibrations (4–30 Hz) should be magnified by a certain factor (estimated as 4.0 in the current investigation) before comparing them to the currently adopted safe limit criteria. This would simulate the resonance or wall rattling which may occur to the houses subjected to ground-born vibrations with low level frequencies. With this modification, Figures 5 and 7 reveal that some of the ground vibrations are significantly outside the safe limit defined by the safe limit criteria and would cause damage to the structures [p. 97].

⁷⁰ E. Y. Sayed-Ahmed and K. K. Naji, “Status quo and critical review of PPV safe limits for subsurface construction blasting close to low-rise buildings,” Research and Applications in Structural Engineering, Mechanics and Computation – Zingone (Ed.) © 2013 Taylor & Francis Group, London ISBN 978-1-138-0061-2 https://scholar.google.com/scholar_lookup?title=Status%20quo%20and%20critical%20review%20of%20PPV%20safe%20limits%20for%20subsurface%20construction%20blasting%20close%20to%20low-rise%20buildings&author=E.Y.%20Sayed-Ahmed&publication_year=2013&pages=93-98.

Gad et al. (2005)⁷¹ presented an investigation which agrees with the reached conclusion of this paper. They investigated the effects of blast vibrations on a single storey brick veneer house, which was monitored for over 1 year and was subjected to 43 blasts with ground PPV ranging from 1.5 to 222 mm/s. They recommended an amplification factor ranging between 2.0 and 4.0 for the ground PPV depending on the PPV value...[p. 97].

Other data collected by Niclson (2005) for residential houses located nearby subsurface blasting had PPVs ranged between 0.06 mm/s and 11.5 mm/s which were well below the 51 mm/s defined by common safe limit criteria. Despite this fact, many complaints of structural/threshold damages were reported which also confirm the conclusions reached in this work [p. 98].

Quarry Blast Initially Mistaken for Earthquake

A blast at the Miller Paving quarry in North Bay on May 16, 2018, was of such a magnitude that Natural Resources Canada mistook the quarry blast for an earthquake.

It seems the experts were baffled by that earthquake/dynamite blast today, but a seismologist with Natural Resources Canada thinks he has the answer. Stephan Halchuk told CKAT this afternoon that the shallow shake was confusing.

"Our instruments recorded shaking this morning in the very near vicinity of North Bay at 9:05 this morning. What our instruments record is the vibrations as they travel through the Earth's surface. Normally we're able to determine the difference between an earthquake, which typically occurs 10 to 20 kilometres below the surface of the earth, and blasts from construction quarries that happen at the surface." But Halchuk says today's event was very shallow.

"So it's hard for us to determine if it's a shallow earthquake or some surface man-made activity. We initially reported this as an earthquake because we can't tell where all the blasts are across the country. There are literally hundreds of blasting sites every day. But since talking with reporters and the local fire chief we've confirmed that there was blasting going on at the exact time, 9:05 this morning by a local company [Miller Paving]."

"This morning a blast shook all parts of the City and was felt as far as Astorville," said Fire Chief Jason Whiteley. "City Departments and the customer service centre were inundated with inquiries. Fire crews confirmed that Miller Paving at their Birch's Road quarry executed a controlled blast to produce aggregate for their upcoming highway project. City of North Bay Departments were unaware that the blasting was to take place today, therefore we could not make the public aware." BayToday phones were flooded with calls from people wondering what had happened. Many thought it was a gas explosion, others a plane or train crash. [update BayToday]

Quarry Blast Vibrations Cause Property Damage and Impact Residents' Health

On March 25, 2015, a massive blast at Pitt River Quarry blew out home doors and some residents suffered ear ringing.⁷²

Lafarge issued a letter of apology and explanation to neighbours of the Pitt River Quarry for a massive blast on Wednesday.

The blast blew open the doors of nearby homes and left some people with ears ringing – at least that was the talk at the rally against a second quarry on Sheridan Hill which took place later that night.

⁷¹ E. F. Gad, J. L. Wilson, A. J. Moore and A. B. Richards, "Effects of Mine Blasting on Residential Structures," *Journal of Performance of Constructed Facilities*, ASCE 19(3): 222-228.

⁷² Neil Corbett, "Gravel quarry sorry for blast," *Maple Ridge-Pitt Meadows News*, Mar. 31, 2015, <https://www.mapleridgenews.com/news/gravel-quarry-sorry-for-blast/>.

The letter explained that unforeseen changes in the weather and air pressure resulted in a much louder blast than anticipated.

Cloud cover dropped after the blast was loaded, and the wind picked up. "We noticed these change in conditions. But since we had already started loading the blast, it is best practice [safety wise] to let the blast go instead of letting mixed explosives sit overnight," said the letter.

The company said the air pressure was outside acceptable tolerances for Lafarge, which it says are more stringent than B.C. Mines....

Blasting Within Regulatory Limits Offers No Assurance Against Property Damage

Residents' complaints of property damage attributed to blasting operations are often summarily dismissed, despite evidence to the contrary, by operators of nearby surface mines on the pretext that blasting is being conducted within regulatory limits.

The mines usually abide by the regulatory limits of 1 inch/second ground movement and 133 dB air blast. Vibration is supposed to be minimized by separating the explosions of each delay by at least 8 ms. Mines usually use a "scaled-distance formula." This limits the amount of explosive per delay period. For example, the limit for a blast 2,600 feet [792 metres] from the closest protected structure is 2,234 pounds per delay period. The closer a mine gets to a house, the less explosive per delay is allowed. The formula does not have to be followed if a seismograph is at the closest house.

When a citizen files a complaint, the DEP [Department of Environmental Protection] inspector, in nearly every case, will write that blasting was within the regulations and go away, leaving angry citizens. They feel as if they are in the Twilight Zone. How can the inspector say blasting is being done properly when their house shakes? Some inspectors have even pinpointed types of blasts that cause problems under these limits, especially air blasts above 115 dB (these are explained in the analysis of each mine below). Yet, DEP and OSM [Office of Surface Mining] refuse to look beyond these standards.

The regulations are based on research done 15-20 years ago by the Bureau of Mines. None was done in West Virginia, and research was with smaller blasts and partly on a new house built specifically to test blasting. Two recent bodies of research have been developed that refute the accepted limits. (I can supply copies to anyone who wishes).

Sam Kiger, Dean of Engineering at the University of Missouri, was the expert for the Bim blasting case, which was tried in court in Boone County in March 1999. Kiger is an international expert in protecting federal buildings from blasting damage. After examining 6,000 blasting logs, he testified that there is about a 95 percent chance of damage at a vibration limit of .5 inches/second, if you count each of the holes shot (50 on average) as a separate vibration. In the Bim case, he also testified that low-frequency waves (2 Hz-11 Hz) generated by some blasts can be more damaging. The frequencies can match that of a house and amplify the shaking.

Freda Harris, who had a blasting case with a mine in Indiana, gathered many documents during the case and subsequent FOIAs [Freedom of Information Act request] of OSM. She wrote a manual for Citizens Coal Council. One of her most intriguing findings was that there can be "hot spots" in a community where the geography can make blasts worse. She emphasizes that damage and vibrations can feel worse if a house's natural frequency is approximately between 4 Hz and 12 Hz. The above-ground part of the house often vibrates more than the ground outside and the foundation. Yet, the DEP/OSM standard is based on ground vibration.

Most of the blasting studies of the Bureau of Mines were done by the David Siskind. The FOIAs provided much correspondence between Siskind and other experts, some of it quite critical. A top official of Vibra-Tech, a leader in designing blasting technology, said: "Any criteria...which ignores the frequency of a structure and the frequency content of the ground motion is overly

simplistic...Your criteria, as proposed, will neither protect the interest of the citizen and the homeowner, nor will it protect the blaster from alleged damage claims."

After the Bureau of Mines was shut down by Congress [in March 1996], Siskind became a private consultant. He testified for the coal company that lost the Bim case. The majority of the blasting cases have overturned his studies, and thereby the limits used by DEP and OSM. As he wrote an OSM official on June 17, 1997: "The battles I am now seeing are not 0.5 in/sec versus 1.0 in/sec. Complainants are trying to dismiss all the science as biased, wrong or nonapplicable. For the most part, they are succeeding in ways that pay off."

Interestingly, the DEP "Surface Mine Blasting Study Guide" acknowledges that the response of the human body is greater at lower frequencies: "This explains why people file complaints even when the blasting is conducted at safe (no damage) levels." The guide recommends seven ways to possibly reduce ground vibration, including: use less explosive per delay, increase the length of delay, detonate the blast away from houses, increase the scaled distance formula. Interestingly, many of the problem blasts violated one of those seven recommendations.

The study guide also notes that blasting complaints will be likely when air blasts exceed 115 dB. It has nine recommendations on how to reduce air blasts, including using enough cover over the explosives in the holes, avoid cloudy days and temperature inversions and avoid open sides in the direction of homes. Again these were often disregarded during problem blasts [p. 15-17].⁷³

Blasting Supervisor Fired Rather Than Put People and Property At Risk

"On April 15, 2003, in an article headlined 'Miner who resigned settles suit' which appeared in the Lexington Herald Leader, Roger Alford of the Associated Press reported":

An Eastern Kentucky coal miner who resigned rather than detonate blasts that could have bombarded homes with rocks will receive \$142,500 from his former employer.

Oat Marshall, who is being heralded as a hero by some coalfield residents, claimed in a lawsuit that he refused to buckle under pressure to violate state blasting requirements...

[Marshall] had said he feared setting off the blasts might have injured people or damaged property in the Letcher County community of Deane...

Marshall, a blasting supervisor, resigned in August 2001 and filed a lawsuit in November 2001 against El Dorado Chemical Co. and Consol of Kentucky, claiming that by pressuring him to violate state requirements the companies had essentially forced him from his job. El Dorado was a blasting contractor for Consol.

The lawsuit was scheduled for trial today [April 15, 2003] in U.S. District Court in Pikeville.

"My client walked away from a good-paying job based on the fact that they had asked him to do something illegal," said Prestonsburg lawyer Ned Pillersdorf [p.9].⁷⁴

Pillersdorf acknowledged...that the settlement had been reached. He also acknowledged the amount of the settlement....

Carla Anderson, of Letcher County, said Marshall should be praised.

"It's a good thing, what he did," said Anderson, who says her home has been damaged by blasting in the McRoberts area....

⁷³ Vivian Stockman, "The Social and Cultural Effects of Mountaintop Removal," Ohio Valley Environmental Coalition, <file:///C:/Users/Windows%207%20PC/Documents/comments-of-the-ohio-valley-environmental-coalition-ovec-po-box-6753-huntington-wv-on-the-compress.pdf>.

⁷⁴ Vivian Stockman, "The Social and Cultural Effects of Mountaintop Removal," Ohio Valley Environmental Coalition.

Proposed Quarry A Potential Nuisance – Injunction Imposed Against Blasting

In *Tinicum Township v. Delaware Concrete, Inc.*,⁷⁵ the trial court issued a preliminary injunction against the quarry operator because, among other reasons, *blasting* would cause a nuisance to nearby residential properties. The trial court's ruling was upheld by the appeals court.

The Township's expert witness, Alperstein, testified that the cliffs above the nearby residential properties were very loose and friable, and that blasting would cause a high probability of rocks dislodging from the cliffs and endangering the lives and property of those below. DVC's expert witness, Chiappetta, stated that the chances of a vibration reaching the boulder above Levinson's house were minimal to non-existent, but he admitted that the boulder was so precariously positioned that a vibration could dislodge it, and he recommended Levinson and his family evacuate their home on days blasting was to occur. Moreover, Chiappetta stated that he never calculated the stress vibrations might place on the cliffs located behind other residences in between the Levinson house and the quarry. Because there are reasonable grounds in the record to support the trial court's grant of a preliminary injunction based on nuisance, we affirm.

In reaching its decision to affirm the trial court's injunction against blasting based on *nuisance*, the appeals court relied on the ruling of the Supreme Court of Pennsylvania in [*Machipongo Land and Coal Company, Incorporated, v. Department of Environmental Protection*, 799 A.2d 751 \(Pa.2002\)](#).

*holding that if mining causes or has a significant potential to cause a public nuisance, it can be prohibited regardless of whether the landowner complied with all applicable statutes and regulations. [*Machipongo*, 799 A.2d at 755](#).*

Homeowners' Wells Near Dewatering Aggregate Pit Impacted

According to neighbouring residents, 16 wells have had water issues since Dufferin Aggregates recently restarted the dewatering process at its Teedon Pit in Tiny Township.⁷⁶

Dufferin Aggregates has applied to expand the Teedon pit along Darby Road in Tiny Township and is requesting to take nearly seven million litres of water per day for aggregate washing purposes....

Dufferin Aggregates, a division of CRH Canada, owns and operates a gravel pit off Darby Road in Tiny Township. With its current water permit set to expire in mid-April, the company has applied for a new 10-year permit to take water for aggregate washing purposes. It is seeking a licence to take 1.6 million litres per day from a well and 5.2 million litres per day from a washing pond 210 days a year....

The fact this pit sits on French's Hill, the recharge area for the Alliston aquifer which is said to contain some of the purest water in the world, is the main source of contention.

"The artesian springs of Springwater, Tiny and Tay Townships represent what is arguably the cleanest natural water on Earth," said Bill Shotyk, Bocock Chair for Agriculture and the Environment at the University of Alberta.

⁷⁵ *Tinicum Township v. Delaware Concrete, Inc. and Mario Diliberto*, 812 A.2d 758 (2002) https://scholar.google.com/scholar_case?case=15752167703902735334&q=golf+or+flyrock&hl=en&as_sdt=2006.

⁷⁶ Andrew Mendler, Midland Mirror, "Area residents protest proposed quarry expansion in Tiny Township," Mar 8, 2018, <https://www.simcoe.com/community-story/8299946-area-residents-protest-proposed-quarry-expansion-in-tiny-township/>.

Shotyk has been testing water from all over the world over the past 25 years and says water found locally is the cleanest water ever tested.

"I have no doubt about the unique quality and inherent value. If we have the best water in the world, why put this valuable asset at risk?" asks Shotyk. "Every effort should be made to protect these aquifers for future generations to enjoy, as they are enjoyed today."...

"This (aquifer) takes very dirty rainwater and cleans it to a supreme level, but there is no value put on that," said Ann Ritchie Nahuis, who noted 16 neighbouring wells have had water issues since Dufferin Aggregates recently restarted the dewatering process...

[Commencing at roughly the same time as the construction of the sump pond (January to May 2009) and aggregate washing operations at the Teedon Pit (which started in Spring 2009) were impacts on water quality in nearby local residents' domestic wells,...

Starting in 2009 the wells began producing turbid (ie. cloudy) water with elevated levels of very fine grained particles. Local residents and experts for the MOECC and the pit owners have simply referred to these very fine grained particles as "silt". To my knowledge there has been no testing to determine the actual particle sizes of the fine grained particles which are turning up in residents' wells, and this is one of many deficiencies in the responses to residents' complaints by the MOECC and the pit owners.

There have been complaints at one time or another since 2009 from a number of residents including the following: - Bonnie Pauze and Jake Pigeon (1189 Marshall Road); - Glenn and Janet Irvine (7062 Highway 93); - Peter and Jenny Anderson (6970 Highway 93); - Kim and Rob Tower (1190 Marshall Road); - David Barkey (30 Darby Road); - Rick Lang (20 Darby Road).

A common theme in many of the complaints including my clients' are episodes of cloudy "or silty" well water which in extreme cases clog filters and destroy equipment. Some complainants have also experienced prolonged periods of abnormally high groundwater levels which have caused local flooding problems and/or well issues.

The responses to these complaints have been very poor. The previous owners of the pit (Cedarhurst) did not appreciate complaints. Complaints were often not logged or responded to (in violation of Condition 5.1 of the PTTW), and when there was a complaint response the company and/or its agents could be aggressively hostile. A scientific approach was absent, and victim blaming was often resorted to.

The MOECC wasn't much better. What I would have expected from the MOECC is a proper, science based investigation of the complaints - unfortunately this has never happened. And rather than admitting to its failings in licensing an aggregate washing operation on top of a hill overlying a vulnerable and valuable aquifer without thinking through the potential consequences, the MOECC has resorted to downplaying and/or ignoring complaints and to criticizing residents for poor well construction/maintenance.

I can see no sign in the record of the MOECC and/or the (previous) site owners' complaint responses of an open mind or of a sincere effort to take the complaints at face value and to conduct a proper scientific investigation of whether there was some possible linkage between what was happening at the Teedon Pit and the complainants' observations of impacts on off-site groundwater resources.

My clients (Bonnie Pauze and Jake Pigeon) have lived at their present location on Marshall Road about 1.4 km downgradient from the Teedon Pit since 1993. They have 2 wells on their property (one for the house and one for the barn), which until 2009 consistently provided excellent quality water supplies. There were no exceptions, their wells simply delivered excellent quality water.

Since the construction of the wash pond (starting January 2009) and the beginning of aggregate washing at the Teedon Pit (in spring 2009), my clients have suffered very negative impacts to the quality of water from their 2 wells caused by periodic episodes of high levels of very fine particles (silt/clay) in their well water. Their February 2015 written complaint which was sent to the MOECC is provided in Appendix 2.

The episodes since 2009 have a seasonal aspect to them. In general, the winter months are good and the wells deliver clear water. Once the snow cover has melted the silt problems can arise. For example after having silt problems earlier in the fall of 2017, since freeze up there was no silt at all in their wells through the winter until an episode which began February 19, 2018 and lasted for about a month. Then it got colder and the wells became clear again and have been so up until the time of my writing this review.

The prior owners' consultant and the MOECC resorted to victim blaming, rejecting any responsibility and telling my clients that the age and/or poor construction of their wells was to blame for any silt problems. This is hard to accept. If there were a problem with the wells' construction, then it would be an ongoing problem. It would not be something that was episodic as has been experienced by my clients. The timing of the problems developing (both wells delivering excellent water until 2009, and then both wells having episodic silt issues since then) is also highly unlikely to have occurred by chance.

The silt episodes seem to be sometimes related to recent aggregate washing activities at the Teedon Pit, but there have been times when a silt episode develops even though no aggregate has been washed recently. My clients have numerous jars and sample bottles full of cloudy water, which they have shown the MOECC and the consultants for the previous owners. Testing by the prior owners' consultants confirmed elevated levels of turbidity and total suspended solids (TSS) in 2015 [p. 10]]⁷⁷

[There have been numerous violations in connection with the three PTTWs issued to allow aggregate washing operations at the site, as documented in Wilf Ruland's report, p. 13-18.]

Balancing Aggregate Extraction Against the Need to Avoid Unacceptable Impacts

In *Mansell Neil Mansell Concrete PL v. Marrochy Shire Council*,⁷⁸ the Planning & Environmental Court of Queensland upheld Council's decision to refuse to issue a quarry permit. The appeals court decision addressed the following issues:

...[B]alancing of need to protect and develop hard rock resource with the need to avoid unacceptable impacts on amenity of encroaching residential development, noise conditions proposed which involve untested technologies; dust, vibrations, flyrock; expectations; precautionary principle; role of Environmental Protection Agency; whether concurrence agency can change it's [sic] response after appeal instituted, issues of protection of environment and visual and character amenity, whether proposal conflicts with planning scheme; whether there are planning grounds; planning need.

The land the subject of the development application is described as Lot 2 on RP165748 and has an area of 18.29 hectares. It is rectangular in shape, except for an irregular southern boundary where it lies adjacent to a concave bend in Zgrajewski Road. Its long axis has a rough north-south alignment, the average side length being approximately 650m and width 300m. The total length of the frontage is 325.07 meters. The northern boundary of the property intersects the summit of the hill where the elevation is approximately 105m. South from this boundary the land drops steeply to the 25m contour over half the length of the block, giving an average slope of about 14°. Over the remaining southern half the land flattens out, reaching a lowest level of about 10m near its south-western corner. The hill is dissected by a number of small gullies fed by springs and flowing into a stream which flows from east to west across the flat southern portion of the property [para. 2]. [See p. 9 Map showing location of proposed quarry.]

⁷⁷ Wilf Ruland, "Review of an Application for a Permit to Take Water for Aggregate Washing at the Teedon Pit near Waverly, Ontario," April 23, 2018, p. 9-10, <http://aware-simcoe.ca/wp-content/uploads/2020/01/April-23-2018-Review-of-Teedon-Pit-PTTW-Application-Wilf-Ruland-P.-Geo..pdf>.

⁷⁸ <https://archive.sclqld.org.au/qjudgment/2007/QPEC07-086.pdf>.

The site is located in an area characterised by either rural activities or native bushland. The rural activities can be divided into two categories:

- Cultivated land either used for sugar cane production or banana growing. Sugar cane generally grown on the flatter floor plain type lands and bananas on the steeper hill slopes.
- Uncultivated but cleared land used either for cattle grazing or left vacant [para. 3].
- Approximately 600 meters to the south of the subject land (at its closest point) and approximately 650 meters from the extractive industry proposed on the subject land is a strip of rural residential allotments focused on Musgrave Drive, Leichardt Drive and Auburn Court [para. 4].

The description given above of the Musgrave Drive and (part of) Leichardt Drive as a “strip of rural residential allotments” comes from Mr Ryter’s report, but this description was not borne out on the inspection of these areas. The Coolum Heights Estate which is serviced by these streets presents as residential development of a very high value with substantial homes built on large allotments with extensive rural and mountain views. There are also residences due south (which is quite close to the Zgarjewski Road frontage), and to the east, including the residences of Kelly O’Shea and Alan Hubbard which are on acreage and share a boundary to the site [para. 7].

Planning Context From a planning perspective, the time for development of the subject land as a quarry has simply passed,

because of the gradual encroachment, particularly in the last 10 years, of residential development which everyone recognises as an incompatible use when associated with a hard rock quarry.

In a joint statement issued by all three town planning experts, the issue was put this way:

In some cases, protection of amenity and environment may result in an extractive resource being sterilised.

The key planning principle in this case is balancing the need to permit the extraction of a valuable hard rock resource, with protection of amenity of nearby residences and the environment. Where encroachment of potentially incompatible land uses has occurred for whatever reason, extra care needs to be taken to ensure the maintenance of amenity [para. 15]. [emphasis added]

The subject land had been acquired by the owner five years before the quarry application was submitted in 2002, and the owner conceded that,

The reason for delaying making the [quarry] application was largely commercial.

As noted by the appeals court, Mr. Schomburgk in his report (Ex17), after referring to the adverse impacts, summarized the position of the Council and the Objectors succinctly (at 5.5.7):

“In my opinion, those impacts (visual as well as noise, blasting and traffic) are likely to change the character and amenity in an unacceptable way. In this case, it will then be a matter for the Court to balance these impacts with the technical advice of other experts. In my opinion, however, the balance in this case favours refusal. Encroaching residential development has simply compromised the ability of this resource to be won without unacceptable impacts on the environment and the amenity of the locality as it is today.”

Council's decision to refuse to approve the proponent's application for a quarry was upheld by the appeals court on the grounds that **the cumulative adverse impacts on the environment and on the amenity of nearby residents outweighed any potential commercial benefits from the proposed blasting quarry.**

Neighbours Attribute House Damages to Blasting at a Nearby Quarry⁷⁹

Homeowners are demanding Hanson Heidelberg Cement Group pay for damages they say were caused by a recent blast....

More than a dozen people said the blast put cracks in their ceilings, walls and driveways. It also fractured their foundations.

It shook my house. It felt like an earthquake in my house," said Joseph George.

For decades the Hanson Heidelberg Cement Group has been conducting routine quarry blasts with little to no problems, but George said that changed Nov. 24.

"It shook like 5 or 6 seconds after the blast went off," said George.

"I have a crack going down the middle of my ceiling. I have sheet rock falling off. It's bad. They are tearing my house up."

But George and others worry most about the damage that can't be seen.

"We can see what is going on inside, but the foundation is the really important thing. Are we on rock or are we on sand or has the rock been turned to sand?" said Dean Livingston, a family member of a homeowner....

An employee of the Hanson Heidelberg Cement Group said a person would be sending a statement soon.

"They did not deny the blast at all," said Livingston.

Livingston said the blast caused cracks and doors not to close at his mother-in-law's house and nothing has been fitting like it used to.

"You straighten a mirror on the wall, and it goes back crooked," said Livingston.

Livingston said the company offered to have an inspector come look at the homes, but he said he'll be getting a second opinion.

"Can you permanently correct this? That's what we don't know," said Livingston.

Quarry Permit Denied in Part Due to Blasting and Flyrock

In rejecting Rivers' proposed quarry on a 93-acre parcel in the Town of Moretown and ruling in favour of the residents (objectors), that part of Vermont Environmental Court's January 2007 decision addressing *blasting* and *flyrock* is reproduced below:⁸⁰

Blasting at the proposed quarry would have several materially adverse impacts upon the surrounding properties and uses, including substantial risks to the Neighbors' water supply from toxic chemical spills and altered groundwater flow patterns, air quality impacts from dust, and aesthetic impacts including noise over 70 dBA beyond the Rivers' property line. These risks and impacts are addressed more fully in other sections of this decision; here we focus only on the hazard that flyrock poses to neighboring properties and uses. [emphasis added]

⁷⁹ Liz Lohuis, "Upstate rock quarry blast blamed for damaging homes," December 11, 2015, <https://www.wyff4.com/article/upstate-rock-quarry-blast-blamed-for-damaging-homes-1/7018879>.

⁸⁰ http://www.killthealbionquarry.org/flyrock_danger.pdf.

Flyrock is rock propelled by an explosion outside of the defined blast area. Flyrock occurs for a number of reasons, including face busts, stemming ejections, and cratering, which in turn are often the result of undetected voids, mud seams, or other anomalies in the rock. Even a very small crack in the rock connecting to a bole [sic] hole can produce flyrock. Flyrock can travel at great velocities over great distances. For example, the flyrock accident described by Rivers' blasting expert in West Lebanon, New Hampshire, caused a head-sized fragment of rock to travel off of the quarry site at over 300 feet-per-second (204.5 mph) and land some 4,000 feet [1,219 metres] away, with other fragments breaking a window and a stone curb at the Technica USA parking lot, some 3,000 feet [914 metres] away from the blast. Mr. Hendrickson testified to five other recent examples of accidents resulting from quarry blasting in Vermont, some of which resulted in pieces of flyrock striking with enough force to become embedded in a metal post and a landscaping rock more than 700 feet [213 metres] away from the blast.

Flyrock is unpredictable and dangerous. Flyrock can travel in any direction or multiple directions from a blast. Rivers' blasting expert cannot guarantee that flyrock will not leave the Rivers parcel, no matter what precautionary measures are taken. Out of concern for the Neighbors' safety, Rivers' blasting expert recommends that anyone within 1,500 feet [457 metres] of a blast remain inside or under cover. It is unclear whether remaining inside would protect against a head-sized rock fragment traveling over two hundred miles per hour. Numerous Neighbors, including Parties Holden, Porter, Hendrickson, Byrne/Farley, McMullin and Sanders, are within this 1,500 [feet] danger zone, as shown on the uncontroverted map admitted as Neighbors' Exhibit N.14. The Holden residence, for example, is a mere 720 feet from the proposed quarry site.

The risk of flyrock is substantial and material, and cannot be eliminated from the proposed project. The risk of flyrock would be present every time there is a blast, i.e., ten or more times a year for 33 years. Errant flyrock could result in injury to or the death of nearby residents, injury to or death of horses at the Mad River Stables on the McMullin property, and damage to homes and property.

Because the risk of flyrock leaving the Rivers parcel cannot be eliminated by Rivers, the risk...[of] property damage, injury, or death will be borne by the Neighbors to the proposed quarry. We cannot condone that shifting of risk onto the long-time residents and farms that have existing in this portion of the Mad River Valley for many years prior to Rivers' pending applications.

Neighbors' Question #12 of their Statement of Questions in Docket No. 7-1-05 Vtec asks: "Whether, under MZR Section 3.5(C), the application and proposed quarry will not cause a hazard to public health or safety?" We must conclude that because Rivers cannot eliminate the risk of high-velocity rock fragments leaving its property whenever a blast is conducted, the proposed quarry will cause a hazard to the health and safety of nearby residents, recreational users of the area, and travelers on Route 100B, in violation of MZR § 3.5(C).

Neighbors' Question #12 of their Statement of Questions in Docket No. 7-1-05 Vtec asks: "Whether, under MZR Section 4.10(A), the land or structure(s) for the application and proposed quarry will be used or occupied in any manner so as to create dangerous, injurious or obnoxious conditions that adversely affect the reasonable use of adjoining or nearby properties?" We must conclude that Rivers proposes to use its land so as to create a dangerous condition that adversely affects the reasonable use of adjoining and nearby properties, in violation of MZR § 4.10(A).⁸¹

Neighbors' Question #13 of their Statement of Questions in Docket No. 7-1-05 Vtec asks, in part: "Whether under MZR Section 4.10(B)(1)-(5), the application and proposed quarry meets the following standards: [...] (3) No fire, explosive or safety hazard shall be permitted which significantly endangers other property owners or which results in a significantly increased burden on municipal facilities." We must conclude that Rivers' proposed quarry creates an explosive and safety hazard which significantly endangers other property owners, in violation of MZR § 4.10(B)(3).

⁸¹ MZR § 4.10(A) reads in its entirety: "No land or structure in any zoning district shall be used or occupied in a manner so as to create dangerous, injurious or noxious conditions that adversely affect the reasonable use of adjoining or nearby properties."

Neighbors' Question #14 of their Statement of Questions in Docket No. 7-1-05 Vtec asks, in part: "Whether, under MZR Section 5.2(C), the application and proposed quarry will adversely affect [the conditional use criteria, including the character of the area and the bylaws in effect]?" We must conclude[] that Rivers' proposed quarry would have a substantial and material adverse effect on the character of the area by introducing a dangerous industrial use into this bucolic neighborhood characterized by single family homes, horse farms, and quiet recreational pursuits. In addition, the proposed quarry would adversely affect the bylaws in effect, including MZR §§ 4.10(A) and 4.10(B)(3).

Neighbors' Question #8 of their Clarified Statement of Questions in Docket No. 68-3-07 Vtec asks: "Does the proposed quarry fail to comply with 10 V.S.A. § 6086(a)(8) because it will have an undue adverse effect on aesthetics, including the scenic or natural beauty of the area, due to noise, trucks, blasting, crushing, drilling, dust, and an industrial scar on the landscape, a scenic landscape that currently supports residential and recreational uses and several horse farms?" We must conclude that the blasting activity on Rivers' proposed quarry would have an undue adverse effect on aesthetics under Criterion 8, even without considering the other proposed quarry activities.

Neighbors' Question #9 of their Clarified Statement of Questions in Docket No. 68-3-07 Vtec asks: "Does the proposed quarry fail to comply with 10 V.S.S. § 6086(a)(9)€ because Rivers has failed to prove that the proposed quarry will not have an unduly harmful impact upon the surrounding environment or surrounding uses and development, and/or because Rivers will not leave the site in a condition suited for alternative use or development?" We must conclude that Rivers has failed to prove that its proposed blasting will not have an unduly harmful impact upon surrounding uses and development under Criterion 9(E).

In accordance with the forgoing, the Court must rule in favor of the Neighbors on Neighbors' Questions 12, 13, and 14 in Docket No. 7-1-05 Vtec and Neighbors Questions 8 and 9 in Docket No. 68-307 Vtec.

On appeal, Environmental Court Judge Durkin issued a 70-page decision upholding refusal of Rivers' quarry permit application, with part of the judge's ruling based on the dangers of blasting and flyrock, as reported by *The Valley Reporter*:⁸²

...Environmental Court Judge Durkin made his decision on Rivers' proposed quarry based in part on Rivers' blasting expert's testimony. The judge wrote in his decision Fact 171, Page 45, "However, Rivers' expert could not assure that no blasts at the Rivers' quarry would result in rock being thrown beyond the Rivers' boundary limits. He speculated that rock could be thrown, unintentionally, as far as 1,500 feet [457 metres] from the quarry floor. Because some homes are located within this distance he recommended that area residents be notified prior to a blast and that they stay in their homes during a blast." In part of the conclusion on Page 62 the judge wrote, "To this area, the Rivers' quarry will bring activities and noises not yet experienced; they will be new intrusions into this neighborhood and district. While the prospect of fly rock trespassing upon neighboring properties will be rare, if occurring at all, Rivers could not provide assurances that fly rock will not descend upon neighboring properties and perhaps onto Route 100B. While Rivers' expert credibly asserts that this is unlikely to happen, he also recommended that those within 1,500 feet [457 metres] of the quarry site remain indoors during blast events. Thus, at least as frequently as a dozen times each operational season, the lives of neighboring property owners will be interrupted and they will be directed to remain indoors, lest they wish to risk limb, life, or property damage. Both the frequency of these intrusions into neighbors' lives and the disparity between such interruptions and the character of this area, leads us to conclude that the project will cause the unduly harmful impacts from which criterion 9(E)(i) seeks to protect."

⁸² Hendrickson, "Quarry ruling did not create unattainable standard," *The Valley Reporter*, June 23, 2010, <https://www.valleyreporter.com/index.php/news/my-view/4537>.

The blasts at Rivers' proposed quarry would be very large. Judge Durkin wrote in his decision "a combined blast could expend as much as 7,848.4 pounds of explosives." (Almost four tons of explosives.)

...[Judge Durkin] concluded, based on the facts before him, that blasting dangers posed an unacceptable risk to the neighbors and traveling public on 100B. He also concluded that the noise coming from the quarry would exceed both Moretown zoning and Act 250 noise standards.

SECTION II – DOCUMENTED FLYROCK INCIDENTS

Flyrock 49	34
Flyrock 50	34
Flyrock 51	34
Flyrock 52	36
Flyrock 53	36
Flyrock 54	37
Flyrock 55	37
Flyrock 56	38
Flyrock 57	38
Flyrock 58	39
Flyrock 59	40
Flyrock 60	40
Flyrock 61	40
Flyrock 62	41
Flyrock 63	42
Flyrock 64	42
Flyrock 65	44
Flyrock 66	44
Flyrock 67	45
Flyrock 68	46
Flyrock 69	47
Flyrock 70	47
Flyrock 71	47
Flyrock 72	48
Flyrock 73	48
Flyrock 74	51
Flyrock 75	51
Flyrock 14 (updated)	52

Flyrock 49

On January 10, 2006, a quarry blast propelled flyrock more than 300 metres and caused widespread damage to buildings and cars, and injured three people. The quarry operator paid a nominal fine of €1,000. (The quarry blaster was fined a sum of €3,000.)

*On the 6 November 2009 at Clonmel Circuit Court, Tipperary, Denis Tarrant & Sons Limited pleaded guilty to one charge. This case arose as a result of a flyrock incident on the 10 January 2006 at the quarry of Denis Tarrant & Sons Limited, Kilfeacle, Co. Tipperary. **The rock travelled over 300m and caused widespread damage to quarry plant, private cars and buildings within the quarry complex. Three people were also injured.**⁸³*

Flyrock 50

On two occasions in 2013 flyrock was propelled onto a busy highway in Virginia where traffic had been stopped prior to initiating each blast.

On both occasions flyrock was thrown onto a busy highway where traffic had been stopped prior to initiating the blast. In May [2013], flyrock traveled approximately 400 feet [122 metres] striking one vehicle and damaging another when it ran over a football size rock that had landed in the highway. In August [2013], flyrock traveled approximately 1,200 feet [366 metres] and landed in the roadway; no vehicles were struck or damaged in this incident. Fortunately, no one was injured in either of these incidents.⁸⁴

Flyrock 51

On December 21, 2010, a blast at the Netley Branch Mine caused a showering of flyrock over a distance of 1,200 feet (366 metres), impacting a county road, trees and nearby homes.⁸⁵

[MSHA Inspector] Belcher testified that the 15 year history of the mine showed that the area was subject to flyrock events....If there had been a history of flyrock events, the [ground control] plan must include greater blasting details....In this case, due to the dangers associated with blasting, rocks were projected between 1,100-1,200 feet through the air and landed near people's homes....One of the rocks fragmented and struck the window of a nearby home....[p. 7].

One home that was affected by the flyrock event...was previously affected by a flyrock event five years earlier....Due to this history, and the proximity of the homes, Belcher believed that there should have been a "heightened awareness of the sensitivity of the area." The Netley Branch Mine had a blast remediation plan prior to the flyrock event cited here. Such plans are put in place once a flyrock event occurs....In the plan, it identifies what went wrong, what led to the occurrence of the flyrock event, and what measures will be put in place to prevent a similar occurrence [p. 7].

...Belcher conducted interviews on December 22, 2010 with homeowners who lived near the mine site....Belcher examined the distances between where the rocks landed and the homes...He found that there were four to five different rocks ranging in sizes from four-by-four inches to 12 by 12 inches. These rocks were scattered on nearby property and Belcher saw the marks on the paths of the rocks....Belcher stated, there were five people in one home and three people in another and said, "fortunately no one was injured or killed, but there was people home at the time [p.8]."

Photographs...showed a rock that broke through part of a window of the house closest to the blast site....This house was approximately 1,000 feet from the blast....The photos also showed splattering on the ground where rocks had landed....The owner of the house told Belcher that the

⁸³ https://www.hsa.ie/eng/Topics/Inspections/Prosecutions/Prosecutions_2009/.

⁸⁴ <https://www.dmme.virginia.gov/DMM/PDF/SAFETY/ALERTS/blastingflyrock/FlyrockHighway.pdf>.

⁸⁵ *Revelation Energy, LLC. V. MSHA*, Docket No. KENT 2011-357-R, Order No. 8257014; 12/21/2010, <https://fmshrc.gov/decisions/alj/KENT%202011-1106.pdf>.

window had been broken by the flyrock in the photo....Belcher interviewed this homeowner, and the homeowner stated that the rock came from the mine on the morning of the blast....Belcher and the homeowner walked around the entire yard, and the owner pointed out the rocks that landed in his yard [p. 9].

According to the photographs, flyrocks landed on a county road, and on other property further from the blast site....The rock was large enough to kill a person if it struck him or her in the head....Other photos similarly showed rocks that had splattered on the side of homes, on trees, and on rooftops [p. 9].

After conducting an investigation as a result of the December 21, 2010 flyrock incident, Belcher discovered that three elements of the [ground control] plan were violated....The first violation that Belcher discovered was that "sufficient burden was not maintained on the side of the shot toward the dwelling."....The burden was the amount of spoil that was either left in place from the previous shot or solid material that had not yet been shot....There was a calculation based on the diameter of the hole to determine how much burden is necessary to help prevent flyrock from traveling as far....Here, the burden and spacing in the ground control plan ranged from 14-17 feet, with a 14-foot minimum....The plan states that "any variance from this minimum requires identification."....No variance was ever requested...[p. 9].

The combination of the three violations...created a situation where the gravity was highly likely and the injury or illness that could be expected was fatal....Belcher testified that the combination of these three violations made the occurrence of a flyrock event more likely than if only one of these violations were present....Even flyrock that does not leave the mine property presents a hazard to miners on the property....Belcher testified that the injury to be expected from such an event would be fatal [p. 11].

The Operator...failed to follow their acknowledged ground control plan to prevent a flyrock event that occurred on December 21, 2010.... A blast remediation plan outlining specific blasting safety pre-caution measures had been previously incorporated into the ground control plan and acknowledged on April 26, 2010. A previous flyrock event...occurred at this same mine on November 19, 2008....The blast was detonated...causing 4 separate rocks measuring between 4 x 4 and 13 x 13 to be cast from the blast and land in the yards of two residences located on Big Blue Springs of Blackberry Creek. One of the smaller rocks...struck the window of a residence occupied by Gary Hatfield. This type of practice presents a high degree of risk of serious injury or death to residents living below the mine. The mine Operator has engaged in aggravated conduct constituting more than ordinary negligence by not following their acknowledged ground control plan...[p. 18].

At the June 5, 2014 hearing, the Commission had difficulty containing its displeasure over the respondent's position that flyrock impacting anyone other than a miner did not constitute a *Significant and Substantial* violation of the Federal Mine Safety and Health Act (Mine Act):

Respondent's argument that a violation may only be S&S [Significant and Substantial] if it can lead to a serious injury of a miner, is both bizarre and incorrect. While it is true that Congress passed the Mine Act to ensure the health and safety of miners, the Commission has never interpreted S&S in such a narrow fashion so as to limit it to the health and safety of miners. Both §104(d) and the seminal Commission cases that developed the criteria for S&S spoke only of the type of injury, not the status of the individual who suffered such injury. [citations omitted] One need not come up with an example that illustrates the absurdity of this position, because this case does so in spades. To say that a violation that placed persons who resided in the path of flyrocks at grave risk was not significant and substantial because they may not meet the statutory definition of miners is absurd. The Mine Act makes no such distinction when persons lives are at risk [p. 22].

Flyrock 52

On April 14, 2011, blasting at a quarry in the process of being redeveloped into a housing project, caused flyrock to be propelled for hundreds of yards causing serious damage to several houses.⁸⁶

Rocks the size of rugby balls were hurtled hundreds of yards from a disused quarry, causing serious damage to several houses.

One householder even found a boulder had crashed through her roof into her bathroom after the botched blast at Barrwood Quarry in Kilsyth, North Lanarkshire.

Nobody was injured, but the four nearby Barrwood Cottages, along with other properties in Ladeside Drive, were hit by falling rocks....

Betty Wilson, 65, who lives in one of the one-bedroom Barrwood Cottages, said: "All hell let loose." Debris was flung hundreds of yards from the blast site, through her roof and into her bathroom.

She said she saw bricks soaring over her rooftop as the blast sent boulders flying up to 400 yards [366 meters] away. Mrs Wilson said yesterday: "I was in my bedroom when all hell broke loose.

"I heard a crashing noise and glass smashing and a brick came through my roof into my bathroom. If I'd been there I would be dead."...

"The worst hit were Barrwood Cottages, right on the edge of the site." Strathclyde Police secured the quarry and a health and safety investigation is due to begin today....

"Debris from the controlled explosion exceeded the perimeter of the safety exclusion zone set by the specialist blasting contractors on site....

Flyrock 53

On May 28, 2014, a blast at the North Bay quarry (1141 Carmichael Drive) operated by Bruman Construction caused flyrock to be projected outside of the blast area onto a neighbouring residential property and near where an employee of Bruman Construction was standing.⁸⁷

Consbec Inc. and Bruman Construction Inc. pleaded guilty to one offence each and were fined \$150,000 for failing to forthwith notify the ministry of a fly-rock discharge into the natural environment, contrary to the Environmental Protection Act....

Fly-rock landed on the residential driveway about 25 feet from where the homeowner and an employee from Bruman Construction were standing. There was no property damage and no one was injured.

Subsequently, the homeowner contacted the ministry to advise of the discharge of fly-rock from the quarry. However, at no time did either Consbec or Bruman Construction advise the ministry of this discharge.

On November 20, 2015 Bruman Construction Inc. was convicted of one offence and fined \$25,000 plus a victim fine surcharge of \$6,250 and was given 6 months to pay the fine. On September 13, 2016, Consbec Inc. was also convicted of the same offence and fined \$125,000 plus a victim fine surcharge of \$31,250 and was given two years to pay the fine.

⁸⁶ Dean Herbert, "Quarry blast terror as rocks crash into homes," April 15, 2011, <https://www.express.co.uk/news/uk/240842/Quarry-blast-terror-as-rocks-crash-into-homes>.

⁸⁷ North Bay Nipissing News, "Major fines handed down for North Bay blasting incident," September 14, 2016, <https://www.northbaynipissing.com/news-story/6857859-major-fines-handed-down-for-north-bay-blasting-incident/>.

[Fly-rock is considered a contaminant under the Environmental Protection Act (“EPA”). Section 14 of the EPA prohibits the discharge of a contaminant into the natural environment. A contaminant is defined under the EPA as something resulting from human activities that causes or is likely to cause an adverse effect. Section 15 of the EPA requires all persons to notify the MOECC if they discharge a contaminant into the natural environment, out of the normal course of events, and the discharge causes or is likely to cause an] adverse effect. What constitutes an adverse effect is broadly defined in the EPA.]⁸⁸

Flyrock 54

On November 30, 2018, blasting for road building in BC’s interior coastal woodlands resulted in flyrock travelling 500 metres and penetrating the roof of an occupied cookhouse.⁸⁹

An Interior Coastal Woodland’s road building contractor had a very serious flyrock incident, with a 6-inch rock penetrating through a cookhouse roof.

The cookhouse was occupied at the time and the rock landed within 6 meters of workers. The blue arrow in the picture...points to hole in roof....

[WorkSafe required] [n]o blasting within 1 km [1,000 metres] of an occupied dwelling. If there is any question as to risk to people, property, aircraft and/or boats STOP and report to Supervisor.

Flyrock 55

On November 27, 2019, blasting at a nearby quarry sprayed flyrock into a Crab Orchard neighbourhood causing extensive damage to 5 residences.⁹⁰

Cumberland County deputies responded to the Market Street area in Crab Orchard yesterday for residences sustaining damage reportedly from a blast from a nearby rock quarry. Officers spoke with Elite Blasting Services that told them there were voids and mud seams, which when the explosion took place, expelled rocks and mud from the blast area. Five homeowners on the 700 and 800 block of Market Street reported damage....:

- Home on 700 block of Market Street – damage to foundation and chimney.
- Home on 700 block of Market Street – damage in two areas of foundation and to a well on property.
- Home on 800 block of Market Street – damage to roof, camper and scattered rocks and mud throughout property.
- Home on 800 block of Market Street – damage to roof and scattered rocks and mud on property.
- Home on 800 block of Market Street – damage to roof of barn, gutters and structural damage to shed and barn. Scattered rocks and mud on property.

The homeowners told deputies this was not the first time something like this happened. There is a seismograph on one property installed to measure the blasts coming from the quarry because of past issues....

[In February 2008,...Crab Orchard residents – 26 whose homes have suffered damages ranging from broken septic lines to septic tanks being raised to hot water heaters being broken by blasts that citizens claim came from the reopening old county rock quarry....Property owners want to know who is going to pay for the damage to their property....”What am I supposed to do about my

⁸⁸ Paula Lombardi, “Failure to Notify brings \$150,000 Fine Despite no Damage to Property,” September 28, 2016, <https://www.siskinds.com/failure-notify-brings-150000-fine-despite-no-damage-property/>.

⁸⁹ <http://www.bcforestsafesafe.org/files/Safety%20Alert-Interfor-Blasting%20Close%20Call-Coastal%20Woodlands-Nov%2030-2018.pdf>.

⁹⁰ Scott Humphrey, 1057 News.com, “Rock Quarry Blast Damages Five Homes In Crab Orchard,” <http://1057news.com/2019/11/27/11/52/46/rock-quarry-blast-damages-five-homes-in-crab-orchard/>.

home?" one woman asked. "I am on \$900 a month disability income. How can I afford [to] fix my house or afford a lawyer?"⁹¹

Flyrock 56

On September 7, 2020, WorkSafe Victoria described a blast at a quarry that damaged buildings on an adjoining property from flyrock that travelled several hundred metres.⁹²

During the firing of a quarry production shot, fly rock ejected from the blast travelled several hundred metres and entered a neighbouring property. Several rock fragments struck and damaged buildings. These fragments narrowly missed employees who were actively working on the property at the time of the shot fire.

Mining and quarrying are high-risk activities. Misfires and fly rock are common hazards associated with shot firing activities, which are routinely undertaken in these industries.

Employers and other duty holders who fail to adequately identify and control the risks associated with shot firing activities can create serious risks to the health and safety of both employees and people in the surrounding areas.

Flyrock 57

On April 14, 1995, an explosion at the Collinson Quarry shattered windows throughout the surrounding area, caused flyrock to penetrate a house and hit a parked vehicle, with minor injuries sustained.⁹³

An explosion at a Knoxville Road stone quarry broke windows, sent a rock through a house, damaged a car and caused minor injuries here Friday, according to Milan police reports.

Police said they received a call at 1:08 p.m. from someone at Collinson Quarry that "an explosion went bad." The dynamite blast did extensive property damage, mostly shattering windows, throughout Milan, police said.

Residents of High Cliff Estates Mobile Home Park, which neighbors the quarry, said the blast shook their homes, knocked trailer skirts loose and, in at least two instances, sent flying rocks into their property.

Police, deluged with phone calls for much of the afternoon, received reports of minor injuries and some gas line leaks. John Bloome, Iowa-Illinois Gas & Electric Co. district supervisor, said that three hours after the incident, his crews had not found any gas line leaks, although the blast had apparently blown out some pilot lights.

Mobile home park residents near East 17th Avenue and 4th Street were apparently hardest hit by the explosion. Several residents said they felt the stronger-than-usual blast and saw a cloud of "smoke" rising over the quarry, which lies directly east of them.

"It was basically like an earthquake," said Doris Davis, park resident.

"You usually hear the booming and you can feel a little bit of a shake . . . but I never felt something like this before," added park resident Dolores Smith.

Ms. Smith's neighbor, Dolores Fouts, vouched that the blast was unusual -- a flying rock struck the car parked in her driveway, leaving a large dent and a pile of powder.

⁹¹ Michael R. Moser, Crossville Chronicle, "Crab orchard residents seek relief from blasting damage," Feb. 5, 2008, https://www.crossville-chronicle.com/news/local_news/crab-orchard-residents-seek-relief-from-blasting-damage/article_bff0ce16-f7b3-5af0-b1c7-dc7791969b34.html.

⁹² <https://www.worksafe.vic.gov.au/safety-alerts/rock-fragments-quarry-blast-impact-active-worksite-neighbouring-property>.

⁹³ https://qconline.com/news/local/quarry-blast-rocks-milan-homes-shatters-windows/article_f36034c0-f1a4-5b8b-844a-e722e0873e04.html?utm_medium=social&utm_source=email&utm_campaign=user-share.

John Bloome's trailer also was struck. He said he could not find the rock that must have caused the fist-sized hole in his trailer, but the projectile knocked a wooden box across the bedroom and shattered a large mirror on the dresser, he said.

Exterior damage to the mobile homes occurred on the sides facing the quarry. Residents said pictures inside were knocked off walls and medicine cabinets were thrown open and emptied.

Scott Schitz, with the Illinois Department of Mines and Minerals, said Milan residents near the flying rocks were lucky. "It will kill people. The rocks fly at tremendous velocity," he said.

The state currently has no law to regulate quarry blasting, although a bill in the House would give the department that power, he said.

"These kinds of complaints are common," Mr. Schitz said.

Callers to The Dispatch and The Rock Island Argus newsroom said the quarry blasts were all too common in their neighborhood and were an accident waiting to happen.

A man answering the phones at the quarry this afternoon said the company blasts dynamite every day. He said he did not know about the property damage in Milan.

"This is a business," he told a reporter. "I've got trucks everywhere. I don't have time for this."

Flyrock 58

On August 23, 2010, a blast at a quarry in Buffalo Township launched an 82-pound boulder into a home nearly a quarter-mile (402 metres) away.⁹⁴

A stone quarry in Buffalo Township was shut down on Monday after a blast sent an 82-pound chunk of stone into a home nearly a quarter-mile [402 metres] away.

The chunk crashed through the roof of a South Bridge Road home's porch. Another portion of stone landed in a yard between Interstate 70 and Route 40.

Authorities said the rock came from Stone Quarry along Route 221.

David Ross told Channel 11 News he was riding his stationary bike he heard two crashes. When he went outside, he saw the rock and the damage it did to his front porch.

"I heard the dynamite go off and then I heard, with a snap of the finger, I heard another crash and that's when I knew something happened," said Ross. "So I came walking out and saw all this debris on my porch."

Not only did the rock rip through the porch, but it tore off the home's siding, too.

"A couple weeks ago we sat out in the yard and waited for the dynamite to go off and feel the vibration in the ground. That's all it was, that's all it has ever been," said Ross.

Ross's neighbor heard the commotion, felt the ground shake and found a rock on her property as well.

"A couple seconds later, I just heard a noise," said Ruth Dewitt. "Sounded like, incoming something. I was looking up. I was trying to figure out where this was. I saw it about 15 to 20 feet above the ground."

The Department of Environmental Protection has halted blasting at the quarry and cited the company after the incident. An investigation is under way.

"They think they hit a pocket of methane gas and it gave it a higher boot," Ross said.

No injuries were reported.

Ross said the quarry company said they will pay for the repairs to his home.

⁹⁴ <https://www.wpxi.com/news/quarry-blast-sends-82-lb-rock-into-buffalo-twp-hom/289213871/>.

Flyrock 59

On September 22, 2010, blasting at an undisclosed location caused flyrock to be propelled 550 metres, penetrating the roof of a Quality Control Lab, and nearly striking two workers.⁹⁵

On September 22nd 2010, at 17hr 10minute an incident occurred at working place of Quality Control lab-Cement testing room near the dam site. The boulder formed at the blasting site of power intake of concrete face rock fill dam (CFRD) which was at a distance of 200m towards north from the face of dam. The size of the boulder was biotite-gniess rock type with dimensions of 3m, 1.5m and 1.6m in respect of length, breadth and height (Figure 3). For the secondary blasting, the boulder was drilled with two holes of 45mm diameter with a spacing of 0.6m and depth of 1.5m. The explosive cartridge of 40mm (390gm/cart.) and 300mm length were used with a detonating cord of 10g/m. After the charging of 1560gm explosive per single hole 0.3m was left for stemming. When the blasting occurred a huge sound was heard and two flyrocks ejected from the boulder which covered a distance of 550m from the blasting site to the Quality control laboratory (Figure 5). Two persons were working in that testing laboratory where the two flyrocks punctured in the iron sheet roof as well as the underneath card board. Fortunately the two fly rocks fell 3m apart from the working personnel in that quality control laboratory.

Flyrock 60

On May 25, 2018, a local paper reported an explosion at a Rhode Island quarry that caused flyrock to damage nearby buildings and injure two people in a town-owned pickup truck parked on a nearby road.⁹⁶

A planned explosion at a quarry in a Rhode Island town sent granite flying into a nearby truck, injuring two town employees.

Authorities say one of the employees of Westerly's Public Works Department suffered head trauma and was kept at the hospital overnight after the blast Wednesday. The other employee was treated and released that day.

Interim Town Manager Mark Rooney says the workers had stopped alongside a road near the blast site to make a phone call when they were hit by flying debris. He says there was some kind of safety failure, but investigators have yet to determine exactly what happened.

A state police bomb squad is assisting in the investigation.

Flyrock 61

On May 5, 2007, blasting at the Kamenica quarry in central Serbia resulted in a massive flyrock incident with flyrock fragments spread over an area of 650 metres.⁹⁷ The structural and environmental damage caused by the flyrock incident, (Figure 8 p. 1090), impacted (a) family house, (b) saw mill, (c) fragment crater, (d) family house, (e) family house, (f) tavern, (g) fish pond, and (h) primary school.

The inspection revealed that flyrock fragments had sizes varying from 3-50 cm and more in diameter and that, on average, there was one fragment per 16m² (Fig. 7).

⁹⁵ A. K. Mishra and M. Rout, "Flyrocks – Detection and Mitigation at Construction Site in Blasting Operation," *World Environment*, 2011; 1(1): 1-5, <http://article.sapub.org/10.5923.j.env.20110101.01.html>.

⁹⁶ Associated Press, <https://apnews.com/article/ed9fa4e1046340c9b6937676d6501ec9> and Westerly Sur, <https://www.newportri.com/article/20180620/NEWS/180629992>.

⁹⁷ Sasa Stojadinovic, Radoje Pantovic and Miodrag Zikic, "Prediction of flyrock trajectories for forensic applications using ballistic flight equations," *International Journal of Rock Mechanics & Mining Sciences* 48 (2011): 1086-1094, <http://tarjomefa.com/wp-content/uploads/2016/05/4694-English.pdf>.

The most severely damaged structure was a two storey family house with several flyrock fragments penetrating through the roof and walls (Fig. 8 position d and Fig. 9).

In the case of the 50 cm fragments, the fact was that fragments did not fall at distances of larger than 320 m. The majority of the 5 cm fragments fell at distances below 300 m but it was not possible to claim with certainty that this was their maximum throw....It must be mentioned that estimation of the velocities for the fragments between 5 and 50 cm was not supported by any calculations. The reason for that was the fact that it was impossible to inspect the whole area affected by flyrock to determine the maximum throw for each fragment size...[p. 1091].

...[T]he maximum throw of flyrock fragments...was 650 m for the 20 and 25 cm fragments. This corresponds to the statements of some eye witnesses that flyrock fragments were falling into a nearby fish pond at the distance of more than 500 m [p. 1093].

The forensic investigation of the flyrock incident **“led to the conclusion that it was necessary to set the safe distance for residents at distance [greater] than 700 m.”**

Flyrock 62

On August 22, 2018, a blast at Camara’s quarry in Castleton, Vermont showered a number of nearby homes with flyrock.⁹⁸

Federal mining officials are investigating a loud blast at Camara’s slate quarry that sent pieces of rock flying onto the front yards of homes on nearby Blissville Road. Some residents of Blissville Road felt the effects of the blast on Aug. 22, but no one was hurt, according to Bruce Sherwin, assistant Castleton police chief. Debris landed on lawns on Blissville Road, he said. Last week a single of piece slate, about 2 inches long, was still lying near the front door of Cecilia Rodriguez’s home, where it landed after the blast. Rodriguez and other residents said they felt and heard the blast at a quarry off Rice Willis Road just before 1 p.m. on Aug. 22. Some fragments also apparently landed on the lawn of Jon Pintelo next door to Rodriguez. Both properties are on the western boundary of the quarry. Lawrence and Jane Nicklaw, who live on Blissville Road next to the quarry, said the blast was bigger than usual. “It felt like the whole house jumped,” Lawrence Nicklaw said. “Everything was rattling, my wife was outside screaming. One of the slate fragments landed not far from where their son, Robert, had been picking cherry tomatoes in the backyard. A larger piece landed along the side of their home,” Nicklaw said. “It hit the ground and shattered,” he said. “Afterward, a blasting company employee rushed to a property next to the Nicklaw’s, picked up fragments and threw them into the high grass,” Nicklaw said. The Nicklaws heard the warning whistle before the blast, but expected only the normal explosion at the quarry. But this blast was big enough to increase the cracking in his Sheetrock ceiling, he said. Explosives are used to gain access to slate deposits. In this case, the blast was fired to remove cover material. “It was a bigger shot than normal,” said David Camara Sr., one of the owners of Camara Slate Products Inc. “I know there was some fly rock.” A federal inspector who investigated the incident found no damage to residents’ homes, according to Jim Petrie, district manager for the Mining Safety and Health Administration in Warrendale, Pa. Petrie said he didn’t know if proper blasting procedures were followed because he had not received the inspector’s report.

Sometimes you can have a well-designed blast and due to weakness in the strata, fissures or voids it may send (fragments) off the quarry you don’t expect to go. Reports of flying rock incidents at stone quarries are a fairly common occurrence, according to Petrie. There have been cases of debris causing injury, he said.

Dyno Nobel Inc. of Symsbury, Conn., was hired to set off the blast in order to remove earth and rock that was covering the usable slate, Camara said. A warning horn or whistle was apparently sounded before the blast, Camara said. Neighbor Fran Chester said she didn’t hear any alarm, but the blast was loud enough to rumble through her house and frighten her. “I thought it was thunder

⁹⁸ Tom Mitchell, Rutland Herald, https://www.rutlandherald.com/news/quarry-blast-sends-slate-pieces-into-nearby-yards/article_258669ca-9aa6-566b-9ca3-e21dab8328d1.html.

or an earthquake," she said. "It would be nice if they notify us." Cecilia Rodriguez agreed. "What if a piece [of flyrock] lands on a kid's head?" she said. "They should be more careful."

Flyrock 63

On July 30, 2018, blasting for a road extension in Hendersonville sent rocks the size of softballs flying into a nearby residential pool and driveway.⁹⁹

State and city officials say they are investigating a blasting incident that sent softball-sized stones into a residential pool and driveway in the Wynbrooke subdivision on Monday. No injuries were reported.

According to Hendersonville Fire Chief Scotty Bush, employees of Charles Dewese Construction, Inc., were cutting a road on the back side of Pilot Knob, connecting to Crooked Creek Lane when fly rock went into a home's pool. The home's owner also reported a cracked window caused by the vibration of the blast, Bush said....

"As part of this process, the blasting firm must now submit a Plan of Corrective Action to the Tennessee State Fire Marshal's Office," added Walters. The plan would include the reasons for the incident and the changes that will be made to ensure another fly rock incident doesn't occur, he said....

"More information must be gathered and a report about the incident must be completed," he said. "When that's finished, this matter will work its way through our complaint process where a recommendation by our legal team will be made about additional steps."

Bush said he plans to meet with Mayor Jamie Clary and the City Attorney John Bradley to see what the city's legal options are as well.

Flyrock 64

On February 4, 2009, a blast at the Lyttelton Dolomite Quarry in South Africa hurled rocks, some the size of car tires, which ripped through a shopping centre, office complex and service station, injuring three people, one of them critically. Hundreds of rocks were showered over a large debris field also impacting motorists and a cyclist.¹⁰⁰

What was meant to have been a routine detonation at the open cast Lyttelton Dolomite Quarry in Botha Avenue on Wednesday left shoppers, motorists and business people running for cover as rocks, some as big as car tyres, rained down on the Doringkloof shopping centre, the Soetdoring business park, a nearby Engen petrol station and cars.

As police closed off roads littered with large chunks of rocks, paramedics and emergency workers raced to treat the injured.

Among the injured was a delivery man who was hit in the chest while cycling past the centre. The rock, which left him critically injured, is believed to have been the size of a soccer ball.

Among the injured was gardener David Maleté, whose leg was broken when he was hit by a rock while watering the business park's garden.

For Martha Chauke, a passing car saved her life. The rock which hit her in the arm and back was deflected as the car drove past her.

⁹⁹ Tena Lee, "Blasting Sends Rocks Flying," Hendersonville Standard, August 2, 2018, https://www.hendersonvillestandard.com/news/blasting-sends-rocks-flying/article_fe3f700c-96bf-11e8-af8c-8736054753e5.html.

¹⁰⁰ Graeme Hosken, "Quarry blast wreaks havoc," February 5, 2009, <https://www.iol.co.za/news/south-africa/quarry-blast-wreaks-havoc-433434>.

As people emerged from their shelter, word quickly spread of extensive damage to nearby buildings and cars. One of the severely damaged cars belonged to undercover police officers who were conducting investigations at the centre. The rock which struck it could be seen lying on the vehicle's floor after it had ripped a huge hole through the back door.

The rock had just missed Malouna Rademeyer's head as she stepped out of her car which she had just parked. "As I got out of my car I heard a 'whoosh' and then a massive bang. I dropped to the ground and began screaming," said Rademeyer. Hundreds of rocks landed around her.

Realising the danger she was in when a rock the size of a soccer ball hit another car, Rademeyer ran for cover. "I was petrified. I did not know what was happening. All I knew was that I had to get to safety," she said.

Rademeyer said some people slipped and fell as they tried to run for shelter.

Businessman Lieb Liebenberg was having a meeting with his daughter, Susan Dry, and a client when the blast occurred. "Everything shook. I thought something terrible had happened. I grabbed Susan and pushed her underneath the table," he said.

As he ran to the mall entrance to see what had happened he was greeted by a wall of dust, stones and rocks hurtling towards him. "I just turned and ran as fast as I could. I didn't have time to think. I did not know what had happened. All I knew was that we were in danger," he said, describing how people caught outside ran as fast as they could to safety.

He said it was absolute chaos.

"Nobody knew what had happened. People were crying and screaming. I saw a man lying on the ground covered in blood. It was a nightmare," he said.

Businessman Gerhard Meyer, who was walking into Soetdoring business park, said the explosion sounded like a bomb blast. "Everything shook. The blast nearly threw me to the ground."

Running into the street he saw a motorist swerving across the road as his car was hit by rocks. "One of the rocks went straight through the windscreen. I thought the guy was dead, but it missed him by inches. He stopped and got out and ran. It went straight through the back of his car.

"It was a miracle he was not killed," he said.

For business colleagues - Elsa Heyneke, Martie Erasmus and Susan Malan - the sound and sight of rocks hurtling through the roof and windows of their office was terrifying.

Erasmus had just stood up to make coffee, when a rock crashed through the roof and landed in the chair where she was sitting minutes before. "It missed me by inches. I heard this massive bang and then there was dust, glass and pieces of roof falling around me.

"I just screamed," she said.

Tshwane Emergency Services spokesperson, Johan Pieterse, said three people were injured by flying debris from the blast.

"One of the injured was critically hurt when he was hit in the chest by a rock while riding a bicycle. Two pedestrians sustained minor injuries, including lacerations and broken bones," he said....

Police spokesperson, Captain Colette Weilbach, said an investigation was under way to determine what had gone wrong during the blast. "The case being investigated will fall under the Explosives Act," she said.

Quarry spokesperson, James Duncan, said the mine along with the Minerals and Energy Department would be conducting a joint investigation.

"At this stage it is not known what could have caused broken rock from the blast in the open pit to fly over the mine's protective wall," he said.

Duncan said mining activities had been suspended.

Flyrock 65

On June 29, 1999, a blast at the Imperial Quarry in Nazareth Township sent rocks over a 200-foot (61 metres) quarry wall and into a residential neighbourhood 1,500 feet (457 metres) away.¹⁰¹

...[T]here was a second mishap that sent rocks over a 200-foot [61 metres] quarry wall and 1,500 feet [457 metres] into the same neighborhood. No one was injured, but both incidents violated state mining regulations and alarmed residents.

"This one surprised everyone. It was a serious blowout," said Gordon F. Revey, a blasting engineer Essroc hired to investigate the cause of both explosions. "It's just astounding to me, because no one did anything grossly wrong."...

Essroc's manager of Pennsylvania operations, Mario Bracci, said his initial reaction after the June 29 incident was to terminate the contract with Essroc's blasting contractor, Mauer & Scott of Northampton.

However, he said Revey's investigation showed Mauer & Scott, which has conducted more than 500 successful shots over the last five years for Essroc, followed standard blasting procedures....

In March, 1999, there was a previous flyrock incident at the same quarry, which hurled boulders 700 feet (213 metres) onto two homes and two cars in the same neighbourhood.

Flyrock 66

In April, 2008, a blast at a Morrisville mine in Vermont hurled flyrock a distance of about 700 feet, with 25 rocks found scattered from Pine Crest Trailer Park to the Morrisville town garage.¹⁰²

A negligent blast at a Morrisville mine hurled rocks almost 700 feet through the air, and could have caused serious injury or death.

That is the finding of the U.S. Mine Safety and Health Administration, after investigating an incident in April on Cochran Road in Morrisville....

In his report, federal inspector Zane Burke said 25 rocks from the mine blast were found scattered from Pine Crest Trailer Park to the Morrisville town garage; some had been flung almost 700 feet.

The rocks "were measured to be 4 to 11 inches long," Burke said, and were found on the lawns of several mobile homes, in front of parked vehicles there, and even on top of the town garage roof, hundreds of feet away....

Mitchell Green, vice president of Maine Drilling and Blasting, said in an interview that the errant blast was an "anomaly" and the result of "unforeseen" circumstances.

"On the day of the incident, we had designed a blast that was very appropriate. We did not feel that mats were called for in this case," he said. "We had established that it was safe."

Green said the blast was designed to shoot rock into a large open face in the quarry, but because of unseen vertical "seams," or cracks in the rock, the rocks didn't shoot forward into the rock face as expected, but up into the air.

¹⁰¹ Tracy Jordan, "June 29 Mishap Caused When Explosives Were Set In a Joint Through The Limestone, Officials Say," The Morning Call, <https://www.mcall.com/news/mc-xpm-1999-09-09-3260561-story.html>.

¹⁰² Jesse Roman, "Blast hurled rocks almost 700 feet," VTCNG, June 12, 2008, https://www.vtcng.com/stowereporter/archives/blast-hurled-rocks-almost-700-feet/article_9c3f1729-96a8-5398-95a5-c5ca9f1610a4.html.

Green said Maine Blasting employees were stationed at the entrance of the mine, on Cochran Road in front of the trailer park, and at the town highway garage, and traffic on the road had been stopped.

"The fact that our people were standing right in front of the park, securing the area, supports the conclusion that the design we put together was safe," Green said....

"We never mat it; we've never been required to mat it," he said. "If we were blasting right next to a car or house, you would, but we're 450 feet away from the nearest trailer. That's a long way."

Burke reported finding rocks as far away as the entrance to the town salt shed, 764 feet from the mine. He said that he found rocks on the front lawns of several mobile homes, and a rock that went 24 feet past one trailer and landed in its back yard.

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Kay Shedd said she was sitting in her mobile home at Pine Crest Trailer Park in Morrisville that late April day when "an awful bang" shook her entire house.

Milliseconds later, she said, she heard another bang; a rock hit the side of her mobile home with such force that two pictures came crashing down off the wall.

"What if a car was driving by, or a kid was riding a bicycle or walking by? What then?" Shedd asked. "I don't think this is good, not at all. This is dangerous and it isn't anything we should have to live with."...

"I'm not so much worried about damage to the house as I am to humans. There are kids walking up and down the street. One of these times, if they keep it up, somebody is going to get hurt," McFarlane said in an interview after the blast.

He said the problems started last year when a stone "a little smaller than a grapefruit" flew over from a blast, and hit McFarlane's companion in the left side, sending her to the hospital,"...

Asked about blasting damage in the past, Percy said 'There was damage in the past to someone's car, but that's why (I have) insurance," Burke wrote.

Burke said Percy told him no damage was reported in the trailer park, but "I informed him (that) I searched the park and found damage to one trailer. He said, 'Ah (expletive)," Burke wrote....

Flyrock 67

On October 1, 2020, blasting at a construction site in Franklin, Tennessee, launched large rocks into nearby homes and yards of Lockwood Glen Neighborhood.¹⁰³

A Franklin neighborhood is safe after large rocks falling from the sky, crashed through homes and into yards in the Lockwood Glen Neighborhood.

"This is unbelievable. Like how does something like this happen?" thought homeowner Stanley Berry after seeing his guest bedroom with a massive hole in the roof and ceiling.

Berry says the blast happened just before noon Thursday as he was downstairs. He thought the sheetrock falling just from the seismic activity but then saw the large rock, split into three pieces across the room.

¹⁰³ Ryan Breslin, "Large Rocks From Franklin Construction Site crash Through Homes, 'It Absolutely Would Have Killed Someone,'" NEWS4Nashville, October 2, 2020, https://www.wsmv.com/news/large-rocks-from-franklin-construction-site-crash-through-homes-it-absolutely-would-have-killed-someone/article_03add48c-051a-11eb-88f6-fff8314e4b28.html?utm_medium=social&utm_source=email&utm_campaign=user-share.

"It was a sheer disbelief. It was a thought of how a company could be so negligent that they would put the residents of this community at risk," says Berry.

He describes his development as very active, with kids outside playing and people walking their dogs. So he knows everyone in the area is lucky the rocks fell in the spots they did. "It absolutely would have killed someone and you know the bigger piece of this too is not only the damage to these homes, because the homes can be fixed, [it's] that it seems like there's a disregard for the lives they put at risk."

Berry says after the rock hit the Lockwood Glen Neighborhood, "original conversations were that, you know, there was negligence in regard to where they placed the blast mat."

Then he reached out to the Department of Commerce and Insurance and the State Fire Marshal's office, who were able to confirm "they did not use blast mats on the shot."

"How do you not put a blast mat down when you detonate a charge? If they've had that kind of negligence, what reassurances can you give us that the other work that they've done back here is not going to end up leaving us impacted in the future?" says Berry.

Not only does he want to see more concern and remorse, he'd like to see a better answer for how his home will be fixed.

"They told me that they were going to make it whole, they said that they were going to come in and do the work, we're going to make sure that you are satisfied, and we're going to make sure like it never happened. And then conversations that I had with the same people this morning gave me the clear understanding that that is not what's going to happen." Berry continues,

"Their intent is to come in a repair the segments that were damaged right, which you would think is reasonable, however at the end of the day, if they only do that it's going to leave a clear mark that the damage occurred, devaluing my property, devaluing my home and not leaving me satisfied."

As someone that just moved into the home two weeks ago and is still unpacking, he wants the investment he just made with his family to be exactly what they bought.

"I would like...the house to be repaired as though this never happened. I don't want it to be a quick fix situation where they send in these restoration companies where they try to come by and say that they'll be here on Monday to make the repairs and left in the situation where I have a constant reminder when I look up in my roof what happened."

Flyrock 68

On May 27, 2020, a blast from a quarry near Senthamangalam, India, hurled portions of a boulder that struck and killed a 10-year old girl, and injured her brother.¹⁰⁴

A 10-year old girl died after a portion of boulder from a stone quarry hit her on [the] head while the quarry operators were blasting a rock with dynamite sticks near Senthamangalam...

The Senthamangalam police identified the deceased as M. Nandhini, daughter of Murthy, 38, of Vaiyappamalai. She was a Class V student of a government school at Paramathi-Velur in Namakkal district.

Pointing out that the girl was staying in a hostel, a police officer said, the quarry operators blasted a rock using dynamite sticks. "Stone pieces flew in the air and hit Nandhini, who was playing outside the house, on her head. She succumbed to her head injuries on the spot. Her brother Soundarrajan was also hit by a stone, fracturing his hand," the officer said.

¹⁰⁴ "Girl dies as boulder from stone quarry hits her on head," TNN, May 29, 2020, <https://timesofindia.indiatimes.com/city/salem/tn-hiv-positive-patients-in-namakkal-district-receive-groceries-for-free/articleshow/76046185.cms>.

Flyrock 69

On November 17, 2011, blasting at a quarry in Tremont, launched flyrock that damaged three nearby homes.¹⁰⁵

The regulation of blasting should be a top priority for the town, planning board members agreed Tuesday.

The issue was put on the front burner by a Nov. 17 blasting mishap at a quarry on Clydesdale Lane owned by John Goodwin Jr. Construction. Rocks thrown by the explosion damaged three nearby homes.

At a Nov. 21 meeting, selectmen directed town manager Millard Billings to discuss the possibility of an ordinance regulating the use of explosives. Mr. Billings got straight to the point when presenting the selectmen's directive to the planning board.

"There was blasting and something went wrong," he said, while giving details on the damage.

Mr. Billings provided planning board members with photos of the damage from rocks – some as large as 12 inches in diameter – thrown from the blast onto properties owned by Tim Rich and Jerry Harper. Mr. Rich was in his bedroom when a large rock crashed through the roof, Mr. Billings said. A third home also was damaged.

"All the damage was property damage," Mr. Billings said. "Luckily, no one was killed."

Flyrock 70

On February 8, 1999, blasting at a quarry in Kyusyu, Japan, caused rocks to fly nearly 300 metres, striking a company car, a factory employee and a roof of a house.¹⁰⁶

...[u]sing DS detonators and #3 Kiri dynamite (31.5kg), some rocks flew nearly 300m away...This incident at the quarry brought about the following damages. (Fig. 5)

- *Human damage:*
A piece of rock cracked through the front glass of a car and then it hit and rebounded upon a driver's door and fell on the right thigh of an employee under operating the car. The degree of injury...was a thigh contusion...
- *Physical damage:*
The front glass and the inner globe of driver's door suffered the damage by a piece of rock. And another piece of rock damaged also to a roof on the factory building. An opening (nearly 4cm) with crazing arose on the slate roof.

Note: The paper also describes two other flyrock incidents at two other nearby quarries.

Flyrock 71

On September 25, 2017, blasting in connection with the construction of Emera's Maritime Link project resulted in flying debris damaging homes in Cape Ray located between 250 and 300 metres away.¹⁰⁷

¹⁰⁵ Mark Good, "Blast damage sparks Regulation," The Ellsworth American, December 1, 2011, <https://www.ellsworthamerican.com/maine-news/blast-damage-sparks-regulation/>.

¹⁰⁶ K. Noguchi, "Fly-rock incidents by blasting at three quarries," *Sci. Tech. Energetic Materials*, Vol. 65, No. 6, 2004: 206-214, http://www.jes.or.jp/mag_eng/stem/Vol.65/documents/Vol.65.No.6.p.206-214.pdf.

¹⁰⁷ Chantelle MacIsaac, "Emera blasting damages homes in Cape Ray," Sept. 30, 2017, <https://www.saltwire.com/news/local/emera-blasting-damages-homes-in-cape-ray-47877/?location=west-coast>.

Jeff Myrick, the company's senior manager of communications and public affairs, said the blast, which is part of routine work on the road leading to the transmission compound station, saw debris damage homes located between 250-300 metres away....

Several homeowners in Cape Ray reported damage from a blast. No injuries were reported.

Flyrock 72

On March 19, 2013, blasting at the M & M Stone Harleyville Materials Quarry sent flyrock across Groff Mill Road.

Pieces of rock, some very large, were thrown across Groff Mill Road....The Department of Environmental Protection has ordered the company to develop a plan by March 29th that will ensure safety.¹⁰⁸

"The investigation revealed that a rock(s) were ejected upwards and outwards from the body of the shot which traveled approx. 381 feet [116 metres] to the resting place," a Pennsylvania Department of Environmental Protection Explosives Inspection Report on the incident notes.

'At least one was the size of a basketball,' Mary West, assistant township manager, told the Lower Salford Township Board of Supervisors...Township police officers stopped traffic on the road during the blasting, although they had not received a request to do so, West said.

Blasting will not be allowed to resume until the quarry submits a corrective action plan 'stating how they will ensure that debris is not ejected into the air for future blasting,' and the DEP approves that plan, according to the DEP's Explosives Compliance Order....

The first notification to DEP was about the level of the blast, but claimed there had been no flyrock. A bit later, the blaster called again and reported that flyrock had left the permitted area,' Fries wrote in an email. The noise level from the blast was registered at 135 decibels, two more than the 133 allowed level, the DEP said....

A Lower Salford officer who lives near the quarry witnessed the blast, Fries said. There is also a video tape of the blast, she said....The DEP put the blast time at 2:51 p.m. Within minutes of that time, a school bus passes down Groff Mill Road, West said.

'We never, ever, ever got a call here that stone left the quarry in the past, but information on what the complaints were about or enforcement actions taken was not immediately available.'¹⁰⁹

Flyrock 73

On April 10, 2009, flyrock was launched from a quarry blast, and struck and penetrated the roof of a residence at a distance of 600 to 700 yards, as reported in *Lakeview Rock Products v. Secretary of Labor Mine Safety and Health Administration (MSHA)*,¹¹⁰

As noted at the hearing investigating the flyrock incident, in reference to the list of factors to be considered in defining the *blast area*, the judge made the following observations:

"[T]he area in which concussion (shock wave), flying material, or gases from an explosion may cause injury to persons. 30 C.F.R. § 56.2 Definitions. The definition continues with the following guidance: "In determining the blast area, the following factors shall be considered: (1) Geology or

¹⁰⁸ "Quarry in Harleyville Ordered to Stop Blasting," WNPV, March 25, 2013.

¹⁰⁹ Bob Keeler, "Harleyville quarry ordered to stop blasting after stones thrown into road," The Reporter, Mar 24, 2013 Updated Nov 14, 2018, https://www.thereporteronline.com/news/harleyville-quarry-ordered-to-stop-blasting-after-stones-thrown-into-road/article_db72eb6a-741e-5383-bcca-cf0ed4e22f4a.html#:~:text=The%20M%20%26%20M%20Stone%2FHarleyville,the%20shot%20which%20traveled%20approx.

¹¹⁰ <file:///C:/Users/Windows%207%20PC/Documents/FMSHRC%20ALJ%20Decision.html>.

material to be blasted. (2) Blast pattern. (3) Burden, depth, diameter, and angle of the holes. (4) Blasting experience of the mine. (5) Delay system, powder factor, and pounds per delay. (6) Type and amount of explosive material. (7) Type and amount of stemming. 30 C.F.R. § 56.2.

The definition of “blast area” can be sharpened to focus on the issue presented here: the flyrock. Using that approach, the applicable portion of that definition is “the area in which flying material from an explosion may cause injury to persons.” While it is indisputable, under the plain text of the guidance, that the enumerated factors are to be considered, the list does not purport to exclude other relevant factors in determining the blast area. Thus the list, while helpful, does not represent an exclusive list of the factors that are to be considered when conducting the ultra-hazardous activity of blasting. Restated, one must not lose sight of the fact that the definition of “blast area” cannot be overtaken simply by a list of factors that are to be considered.

The circumstances surrounding the flyrock incident are described as follows:

...On April 10, 2009, at about 2:45 p.m., Lakeview “conducted a blast in an area high up on the east end of the mine’s highwall.” Sec. Br. at 3. That blast produced flyrock which penetrated the roof of a nearby residential home which was located off the mine site. The flyrock then proceeded to travel through the home’s attic and ended up in the home’s living room. That home, a new residence, some 600 to 700 yards away from the detonation site, was situated above the mine’s highwall.

A matter of good luck, although the homeowners’ three children were home at the time of the blast event, as was their mother, no one was injured. To be precise, and as noted in the citation itself, the flyrock minimally penetrated the living room’s ceiling, “coming to rest just beneath [the] gypsum wall board lining the inner ceiling of...the living room.” The homeowner testified that some small particles reached the living room floor...The fact the flyrock pierced the roof is ample evidence of the seriousness of the event.

The Secretary contends that, to comply with the standard, there must be ample warning given to those within the “blast area.”...She looks to the definition of that term, “blast area,” which, as previously noted, is a defined term, and concisely expressed as “the area in which concussion (shock wave), flying material, or gases from an explosion may cause injury to persons.” The Secretary emphasizes that in this instance there is no need to speculate whether the flyrock could have caused an injury, since the rock not only reached the residence but pierced the structure itself. As damage actually happened here, the facts go beyond the situation where such material may cause injury, progressing to the point where it did cause damage to a residential home, and therefore the Secretary contends that the home was indisputably within the blast area....

In holding those conducting blasting accountable, courts frequently invoke the principle of *res ipsa loquitur* [the principle that the occurrence of an accident implies negligence]. These principles have been long standing. For example, in *Rote v. Bellefonte Furnace Company*, 37 Pa. C.C. 315, 1906 WL 2951 (Pa. Comm. Pl.) (1906), homeowners close to a quarry had their dwellings hit by rocks produced by blasting. The mine failed to give notice of its blasting to the homeowners. As with Lakeview, the mine contended that it had “conducted [itself] along the safest and most careful lines known to the business.”...However, the Court observed that “[s]uch blasting without ample warning is always dangerous, and might be fatal,” and it concluded that liability attached regardless of whether any negligence was involved....Similarly, in *Allegheny Coke Co. v. Massey*, 174 S.W. 499, 163 Ky. 792, (March 26, 1915), the Pike County Circuit Court held that where blasting cast a rock upon one’s dwelling, the mine contractor was liable, regardless of negligence. There, ample warning was given before the blast and the family ran into their home. Unfortunately a rock went through a window, blinding a child in one eye. The point is that, where the activity is blasting, liability was found to be absolute. The Court observed, “it makes no difference whether precautions are used or not to prevent the injury...the act itself is a nuisance.”...

Thus, the cases involving blasting examine only whether harm resulted and hold those conducting that activity strictly liable. Accordingly, in cases such as *Garland Coal & Mining Company v. Few*, 267 F.2d 785 (10th Cir. 1959), an action by a landowner for damages from the adjacent mine’s blasting activity was upheld on a strict liability basis and that strict liability extended to more than flyrock, as it included damages from concussion and vibration. This has been the longstanding

result in American jurisdictions where blasting operations produce harm; there is no duty to establish evidence of a breach of a standard of care to establish liability for harm from such activities. *Smith v. Yoho*, 324 P.2d 531, 533 (Okla. 1957), *Ward v. H. B. Zachry Const. Co.*, 570 F.2d 892, 895-96 (10th Cir. 1978). Thus, **it seems an anomaly that, in the context of the remedial statute that the Mine Act is, liability for harm associated with blasting activity would be more burdensome to establish than in a common law proceeding. Obviously, adopting such a view would require a revisiting of the Hobet standard. However, if a strict liability approach were to be applied in instances such as Hobet and Western Mobile, mine operators would likely react with a more stringent approach in terms of these blast warning standards and situations such as the significant injuries in those cases would likely be reduced. So too, homes, such as the residence in this case, would be less likely to be assaulted by flyrock from blasting.** [emphasis added]

For its part, Lakeview contends that, at the time of the blast, it had no reasonable basis on which to extend the blast area to include the home, even though it acknowledges that the flyrock penetrated the structure's roof, proceeded through the attic and ended up in the family's living room. Lakeview relies upon the recounting of its blaster, who stated that the blast in issue was "nearly identical to prior blasts in the same area" and consequently it contends "that [the blaster, Robert Hylemon] acted reasonably and prudently with the 'blast at issue.'"...Accordingly, Lakeview asserts that, as the blast in question was only ten feet away from the previous blast and nearly identical to that earlier blast, it would be unreasonable to hold the mine liable under the cited standard and to expand the blast area simply because of the flyrock result here....Thus, ultimately, it is Contestant's position that the Citation should be vacated on the basis that the Secretary failed to meet her burden of proof....

In its Reply, the Secretary contends that Lakeview has missed the central point that its failure was not correctly determining the actual blast area....Thus, Lakeview's notifying those within the blast zone it identified means nothing if it incorrectly identified the zone itself. Instead, the Secretary contends that the appropriateness of a blast zone is a blast-by-blast test, employed by an experienced mine blaster. In responding to Lakeview's claim that the blast was "not unusual" from the other blasts it had detonated, the Secretary disputes that characterization, arguing that the location of the blast was certainly unusual due to its being located in the upper northeast corner of the highwall and so close to the recently built residences. The Secretary points out that even Lakeview's Hylemon acknowledged that proximity to residences is a factor a blaster must consider. Yet Hylemon, the one who needed to know such information, did not even know of the existence of the nearby housing. A prudent blaster, the Secretary submits, should have examined the top of the highwall and thereby become informed as to what was above the spot where the blast was detonated. Without taking that action, Lakeview cannot claim that it made a proper assessment of the location of the blast....

Lakeview Rock's blaster, was asked about his consideration of the nearby residences and he admitted that not only did he not consider the nearby homes, he did not even know of their presence, let alone their proximity. Thus, when the blaster was asked if he had calculated how nearby any residence was to where he was blasting and if he knew that a house had recently been built at that the location where the flyrock landed, he responded that he did not.... Nor did he go to the top of the pit where he was blasting and look around to see if anything new was up in that area....The blaster also acknowledged the authoritativeness of the reference book, "Explosives and Rock Blasting," though he was only "vaguely" familiar with it...Importantly, the blaster agreed that "proximity to residences" is something a blaster should consider when planning a blast...

It is worth remembering that this case is not in the realm of speculation. Thus, there is no argument disputing that the blast occurred, that flying material left the mine site, that it landed on the house with sufficient force to penetrate the residence's roof, not coming to rest until it reached the family's living room....The Secretary therefore contends, and the Court agrees, those undisputed facts demonstrate that the home was within the blast area.

... Hylemon not only failed to calculate and therefore consider the proximity of the residences to the blast site, he did not even know the homes were there. Had he examined the area above the top of

the highwall, as he should have, he would have discovered the home sites. Further, while Hylemon asserted, in effect, that this was a one of a kind event and therefore, implicitly, unpredictable, the Secretary, as previously noted, observes that even after the event, Hylemon had no idea that flyrock had hit a residence until mine management so informed him the following day. Therefore, his testimony that this event was unique is unsupported. Given these undisputed circumstances, the Court agrees that Lakeview's failures constituted at least moderate negligence...

Despite the quarry operator being found guilty of “moderate” negligence under the Mine Act, the flyrock incident had the potential of injuring or killing the occupants (including three children) of the residence, for which the quarry operator was fined a nominal sum of \$1,000! The financial penalties for the same flyrock incident in a common law proceeding (not governed by a remedial statute) would have been substantially higher, as blasting is deemed an ultrahazardous activity held to a strict liability standard.

Flyrock 74

On July 16, 2007, flyrock debris from a blast at the Three Mile Mine in Pike County, Kentucky, struck and killed Bobby Messer, a mechanic standing 1,586 feet (483 metres) from the blast, and flyrock debris damaged his truck.¹¹¹

...[O]n July 16, 2007, Bobby Messer, a 40-year old mechanic received fatal injuries when he was struck by fly rock from a production blast...The fly rock that struck the victim travelled approximately...[1,586] feet, into an area where miners parked their vehicles and mine equipment between shifts. The fly rock passed over a 50 foot embankment prior to reaching the accident site (Appendix II). Although several pieces of fly rock were found at the accident site, the size of the rock that struck the victim could not be determined....

Other pieces of fly rock, including one approximately 16 inches x 20 inches (see measured from an imprint in ground) hit within a few feet of where the men were standing. The rock appeared to have broken on impact with the ground, with smaller pieces bouncing in a fan like direction. Fly rock also struck the adjacent mechanic's truck resulting in several areas of damage....

The fly rock at this mine was a high angle, blow-out type of fly rock due to the terrain between the blast site and the impact area(s) and the impacted fly rocks continuing path after impacting the ground.

Flyrock 75

On November 5, 2001, a blast at the Manitou Sand and Gravel pit showered large rocks 4 inches to 20 inches (“a good 15 to 20 pounds”) upon the residents in the neighbourhood south of the pit. A prior blast on September 17, 2001 also resulted in flyrock.¹¹²

On November 5, Dolomite, leasor of the Manitou Sand and Gravel pit, conducted a blast to open a new lift (or level) in the quarry floor. That blast, as well as earlier blast on September 17, resulted in flyrock. According to Shirley Zicafoose, "Large rocks were rained upon residents to the south of the pit. Rocks as large as 30 pounds were blasted out of the pit onto adjacent property." Upset by this occurrence, Zicafoose called the police, contacted Ogden Supervisor Gay Lenhard and wrote a letter to Suburban News.

The police report substantiated Zicafoose's concern and stated that the 'Rocks ranged in size from 4 inches in diameter to 20 inches in diameter (a good 15-20 pounds). It also stated that, "Any of the

¹¹¹ MSHA Flyrock Investigation, <https://arlweb.msha.gov/FATALS/2007/ftl07c09.pdf>.

¹¹² “Flyrock from Ogden mining site causes neighborhood concerns,” <https://westsidenewsny.com/pastarchives/OldSite/westside/news/2001/1217/features/flyrock.html>.

rocks certainly could have caused injury or death to anyone that could have been hit while in the yard. Structures and cars are also subject to damage."...

John L. Swierkos, Jr., geologist and environmental coordinator at Dolomite, responded to the DEC [NYS Department of Environmental Conservation] in a letter saying, "It's not our intention to have an incident such as this to ever occur. This was an initial development blast rather than a normal production blast." He said, "Upon inspection we did find flyrock. No matter what kind of blast we are doing, this is unacceptable."...

Flyrock 14 (updated)

On April 11, 2011, blasting at the Cookeville Limestone Quarry hurled debris and an 86-pound boulder that crashed through the roof of the Hudgens' residence at 1250 Skyline Drive, 407 feet (124 metres) away.¹¹³

...[On] April 11, 2011, a blast was needed at the top of a highwall to clear cap stone and create a ramp that would make the area accessible to heavier equipment....In creating the blast design, it is necessary for the blaster-in-charge to consider the minimum distance to any nearby structure that people inhabit, such as a home or a school, and makes [sic] adjustments in the amount of explosives to ensure that flyrock does not reach the structure....In the present case, the blaster-in-charge identified the home of Roy Douglas (Doug) Hudgens and Sarah Hudgens as the nearest inhabited structure. The Hudgens' home was 407 feet away from the blast site.....

On April 11, 2011, at 12:15 p.m., Mr. Hudgens arrived at his home for lunch....When Mr. Hudgens entered his home, he observed a cloud of dust in the air, appearing to originate from his bedroom....Once in his bedroom, Mr. Hudgens observed a large rock, later determined to weigh 86 pounds, and a hole in the ceiling, where the rock had entered through the roof....The rock crushed a chest of drawers on impact and caused extensive damage to the home, including knocking out a window, creating cracks on the inside and outside walls of the home, and strewing insulation, remnants of ceiling joists, and other debris across a 10 foot area of his bedroom....A rocking chair next to the drawers was covered in at least a foot of insulation pulled down from the ceiling by the rock....

The flyrock landed over 400 feet from the site of the blast....Previous blasts at the Cookeville Limestone Quarry caused dust to be carried up the hill to his home and neighbors' property, covering cars and porches, but, in those instances, the Hudgens' home was not physically damaged....Prior to April 11, Mr. Hudgens claimed that he experienced shockwaves and the smell of noxious fumes originating from the quarry at least once a month, though he agreed that he never had to be treated for dust or fume inhalation by a doctor....However, Mr. Hudgens testified that a neighbor, Asher Lefebvre, experienced breathing difficulty due in part to the effect of dust....Mr. Hudgens also testified that shockwaves from blasting caused damage to the doors, windows, and bricks of the Lefebvre home....

On April 11, 2011, Sarah Hudgens was at home, reading in her bedroom rocking chair, until some time after 11:00 a.m....She left her home at 11:30 a.m. for a lunch date and did not return until approximately 1:00 p.m....When she returned, she observed extensive damage to her home caused by the 86 pound rock that entered through the roof....She described damage to clothes and a bed, as well as the insulation covering much of her bedroom....She testified that she was provided with no warning on the day of the blast or any day prior....

On April 14, 2011, Blair traveled to the Cookeville Limestone Quarry to determine if a previous citation should be extended or terminated....Upon his arrival, Randy Livingston, the Cookeville Limestone Quarry manager, told Blair that "he would have to have an extension on the clearing [of] the top of the shot area because the first time they shot it they hit a house off property."...Livingston

¹¹³ Secretary of Labor, Mine Safety and Health Administration (MSHA) v. Austin Powder Company, Docket No. SE 2011-583-M, A.C. No. 40-0080-256299 E24, https://www.fmsihrc.gov/decisions/ali/ALJ_12172013-SE%202011-583.pdf.

had not previously notified MSHA that the house had been damaged because there is no reporting requirement for flyrock if there is no injury....Blair reviewed the drill records and the partial shot record that were provided by Austin Powder and examined the blast site....Blair observed mud in the woods near the blast site, which he attributed to the shot going in the wrong direction....Blair also reviewed a video of the blast in which he observed the material shooting straight up from somewhere near the center of the blast site....Blair found this to be an indication that either the drilled holes were overloaded or the stemming failed....

Blair assessed the type of injuries that could result from the violation as a person being fatally injured by flyrock....In Blair's opinion one person, Mrs. Hudgens, was affected, though he acknowledged he could have found that both Mr. and Mrs. Hudgens were affected....Blair indicated that although the citation was written as "low negligence," he would have written it for "high" or "reckless disregard" after learning more of the facts....Specifically, he would have issued the citation for a higher level of negligence if he had known the amount of dirt that was drilled through to sink the blast holes and the type of stemming that was used to fill the tops of the holes....Blair also testified that rock was protruding above the ground at the site, which signaled to Blair that the area was "backfilled" with rock and dirt....Blair believed the backfill mixed with the cap stone increased the potential fly material and should have resulted in the blast area being doubled or tripled in size to avoid injury....Blair also found that the violation was S&S [significant and substantial] because Blair believed that it was reasonably likely to cause an accident and the injuries were reasonably likely to be serious or fatal....

Blair testified that if he had been the blaster-in-charge, he would have doubled or tripled the blast area, which would have included the Hudgens' home, to prevent injury....He believed that the blast area should have been extended to at least 800 feet because of "the way they stem the hole[s], [and because of] the loading process of the holes"....He added that an area was cleared 500 feet in the direction of the mine property, but not the same distance in the direction of the Hudgens' home....He stated that the home was 407 feet from the blast site....

Clark testified that in his opinion the Hudgens' home was in the blast area based on his application of the Section 56.6306(e) requirements to the Austin Powder records of the April 11, 2011, blast...."[B]last area" is defined in Section 56.2 as "the area in which concussion (shockwaves), flying material, or gases from an explosion may cause injury to persons." Under Section 56.2, a blast area is determined by considering these seven factors: 1) the geology or material to be blasted, 2) the blast pattern, 3) the burden, depth, diameter, and angle of the holes, 4) the blasting experience of the mine, 5) the delay system, powder factor, and pounds per delay, 6) the type and amount of explosive material, and 7) the type and amount of stemming. Clark's analysis of what constituted the blast area on April 11 focused on three of the seven factors....In his view, the geology to be blasted, the blasting experience of the mine, and the type and amount of stemming, were inadequately considered before the shot was fired....He did not believe that the other [four] section 56.2 factors were at issue....

In examining the first factor, geology to be blasted, Clark reviewed the records and described the pre-blast geology of the drill area as "rock with a lot of dirt."...In Clark's experience, since dirt is not a solid material, the blaster-in-charge must compensate by adding more stemming to the bore hole and by ensuring the explosives are not put into the dirt portion of the bore hole....Clark also testified that the amount of dirt in the drill area made the geology unpredictable which should have require[d] that the blast area be expanded further than 407 feet in the direction of the Hudgens' home....

Clark explained that the fourth factor, blasting experience of the mine, refers to the history a miner (blaster) has blasting in an area. If experienced blasters have a routine consisting of similar loads and conditions, the mine and the blaster would expect consistent results....If the conditions are dissimilar, like the mixed dirt and rock conditions on April 11, Clark expected that the blaster would require an extension of the blast area, as the blaster would find the blast less predictable....

Clark described the seventh factor, type and amount of stemming, as relating to the inert substance that is put in the blast hole on top of the explosives in order to hold the energy of the explosives within the rock....In his opinion, drill cuttings comprised of dirt and rock, as was used in the April 11

blast, are “not a good stemming material.”...Clark testified that the stemming could have significance in how the blast area should have been determined....

Clark admitted that during his time as a blaster-in-charge, he had unintended incidents of flyrock, but the rocks did not leave the blast area....Rather, the flyrock landed in an area where he knew it had the potential to land. In his opinion, the blast area was anywhere the flyrock had the potential to land....

Clark also testified that the duties contained in both Sections 56.6306(e) and (f) are meant to apply to the protection of all persons in the blast area, not just to miners or to persons on mine property....Clark stated that when he was a blaster-in-charge, his practice was to notify the mine operator prior to the detonation so the operator could alert its employees to evacuate..., but Clark recognized that the blaster-in-charge is ultimately responsible for the safety of the blast....

John Capers is a corporate technical manager for Austin Powder Company....Capers was admitted to testify as an expert in the field of explosives....Capers explained Austin Powder’s application of the seven Section 56.2 factors for determining a blast area....In addressing the geology of the area, Capers provided examples of geological formations, and explained that within a quarry, the geology is slightly different on each bench....He stressed that blasters are limited to what they can see visually in determining the stability of the geology of the blast area....

Capers testified that the blast report demonstrates that the blaster-in-charge knew the nearest protected structures, private residences including the Hudgens’ home, were to the north and the blast was directed due south away from the structures....

Capers concluded the flyrock originated from a group of underground broken rocks located six to twelve inches away from the solid bore hole, but he could not determine if the fly rock came from the explosive area or the stemming area....Capers later contradicted his testimony and said “the rock did not come from the stemming area,” in support of his statement that crushed stone stemming would not have prevented the flyrock.... Capers testified that after watching the video of the blast, he concluded the flyrock was caused by a hole located toward the rear of the shot....However, upon cross examination, Capers testified the flyrock incident was not a “blast back,” when the rock goes in the opposite direction, because the flyrock “wasn’t caused by material ejecting to the rear of the shot. The flyrock was from the evacuation of a hole almost in the center of the blast [and] went straight up.”...

Frady [the blaster] acknowledged the chance that rock would not travel in the direction he intended, but he did not consider it a “reasonable” or “likely” possibility....Frady emphasized that the blast design was for “nothing to go back” and that there were no previous reports of flyrock in the wooded area around the quarry....When clearing the blast area, Frady stated that he only checks the direction that he designed the shot to shoot....Therefore he cleared the mine shop, which was located 400 to 500 feet to the south of the blast, in accordance with the blast design....

Frady testified that he ensured that the Cookeville Limestone Quarry workers left the quarry with their equipment at 11:30 a.m. on April 11, and that he shot the blast at 11:45 a.m....When asked why he did not inform the homeowners of the blast, Frady said he did not know the local homeowners because he was “going to a different quarry every single day in a different county.”...Frady recorded the initial blast report immediately after the blast, but explained that he made changes to the original blast report sometime after 5:00 p.m. on the night of April 11, 2011....He made the changes to give more detailed information on the blast and to update the report to include the flyrock incident....In Frady’s opinion, the flyrock came from “sort of the middle of the shot in the back corner[,] [b]ut it almost look[ed] like it c[ame] just in the middle.”...

Frank (Randy) Livingston is employed as the quarry manager and supply superintendent at Cookeville Limestone Quarry....Livingston testified that Austin Powder blasts at the quarry twice a month on average....Livingston indicated that the section of the quarry where the April 11 blast occurred had been blasted before on different levels, although he could not recall how many times....Livingston acknowledged that “a fly rock of any size can go at any time off of any shot loaded by anybody.”

Austin Powder has a long history of violations consisting of “241 violations between January 4, 2007, and April 20, 2011,” and for causing the flyrock incident, an 86-pound boulder crashing through the roof of a neighbouring home with the potential to injure or kill the residents, the blaster received a poultry fine of \$4,689. The environmental court’s overriding concern was not to protect nearby residents from the potentially deadly effects of flyrock, but rather to ensure that “the proposed penalty will not adversely affect the Austin Powder’s ability to continue in business.” This misguided concern despite the court acknowledging,

The...flyrock entered the Hudgens’ home with sufficient force to break a hole in the roof and smash several pieces of furniture, interior walls, and windows. Indeed, the 87 pound rock landed within a few feet of where Mrs. Hudgens had been sitting. If she had not left her bedroom shortly before the blast, it is reasonable to conclude she would have been seriously injured or killed [p. 21].

As for the degree of negligence assigned to Austin Powder for this potentially catastrophic flyrock incident, the environmental court concluded only that “Austin [sic] Powder’s negligence was ‘moderate.’” Without any rational explanation, the flyrock incident was downplayed to ignore the potential of more than one person being fatality impacted. Further, no legal duty was imposed on the quarry operator to increase the blasting safety zone by a factor of two to three (800 feet to 1,200 feet), consistent with the inspector’s finding, and to protect the entire Hudgens’ family (and visiting relatives and guests) from future flyrock incidents.

...[T]here was a reasonable likelihood that the injury in question would be of a reasonably serious nature. I credit Inspector Blair’s obvious observation that flyrock can crush a person and produce a fatality....The violation was S & S [significant and substantial]. The violation was very serious. I credit the inspector’s testimony that fatal injuries could result from not warning and clearing persons in a blast area and thus allowing them to evacuate....Persons affected by the violation are subject to the hazards of flyrock. The inspector found that one person usually is affected, based on his opinion that “most of the time it’s only one person that gets hit.”...[Flyrock always has the potential to injure or kill more than one person] In this case, the person was Mrs. Hudgens....

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President, International Forensic & Litigation Appraisal Services Inc. and
International Valuation Consultants Inc.

Email : info@intval.com Web site : www.intval.com