

Running List” of Flyrock Incidents – The “Hits” Just Keep on Coming

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Introduction

The aggregate extraction industry and its explosives engineers are notorious for either ignoring or downplaying *flyrock* by constantly characterizing flyrock as a “rare” event. In Ontario, *flyrock* is an undefined term under the *Aggregate Resources Act* (ARA), and the Ministry of Natural Resources (MNR) has never undertaken a quantitative study of flyrock incidents, even though flyrock is the most dangerous aspect of blasting rock. Compelling evidence is presented, which shows that flyrock is an unavoidable by-product of blasting (i.e., detonation of explosives), and can never be reduced to “zero.” Flyrock has been known to damage personal and real property, and to injure, permanently disable or kill people (children, women and men) both onsite and offsite. Flyrock launched offsite onto publicly- or privately-owned third-party property constitutes *nuisance* and *trespass*. This paper provides a “running list” of flyrock incidents as a continuation of previous research addressing flyrock, and should be read in conjunction with *Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required* (Sevelka, 2022).¹

Characteristics of Flyrock – An Unavoidable By-product of Blasting (Detonation of Explosives)

Flyrock is the ultimate *adverse effect*, and is the most dangerous aspect of blasting (detonation of explosives) to break rock. Blasting is an *ultrahazardous* activity, and as blasting within regulatory limits cannot prevent flyrock, the activity is held to *strict liability* or *The Rule of Rylands* by the Courts. Flyrock can launch a considerable distance and in more than one direction from a blast site and at great speed. The characteristics of flyrock, and the potential consequences (*adverse effects*) of flyrock on the *environment*, including the people who live, work, shop and play near a blast site, are detailed in the following sections of this paper.

“Flyrock” means rock that is thrown through the air as a result of blasting [i.e., detonation of explosives].²

“Flyrock can be gravel, rocks, tree trunks, construction materials, mud – even water.”³

¹ Sevelka, T. (2022) “Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required,” *Grassroots Journal of Natural Resources*, 5(4): 66-98. <https://grassrootsjournals.org/gjnr/nr-05-04-05-sevelka-m00318.pdf>.

² Nova Scotia, Canada, website: <https://novascotia.ca/lae/healthandsafety/flyrock.asp>. In Ontario, *flyrock* is an undefined term in the *Aggregate Resources Act* O. Reg. 244/97, s. 0.13 (1) 28, requires that *reasonable* (undefined) steps to prevent *flyrock* only if there are *sensitive receptors* within 500 metres of the boundary of the site (s. 0.13 (1) 28).

³ Worker’s Hazard Alert issued by the National Institute for Occupational Safety and Health (NIOSH), 2019.

Flyrock from surface blasting operations has caused serious injury and death to employees and other persons.⁴

[T]he discharge of fly-rock caused an “adverse effect” under paras. (b) and (g) of the definition, [s. 1(1) of the Ontario EPA] namely, it caused injury or damage to property and loss of enjoyment of the normal use of the property. Because the reporting requirement is also engaged when the discharge is “likely to cause an adverse effect,” para. (e) is also applicable since the potential existed for “impairment of the safety of any person.” The adverse effects were not trivial. The force of the blast, and the rocks [flyrock debris] it produced, were so powerful they caused extensive and significant damage, penetrating the roof of a residence and landing in the kitchen. A vehicle was also seriously damaged. The fly-rock could easily have injured or killed someone (Castonguay, 2013, Supreme Court of Canada).⁵

Any blasting event in surface mines produces a sudden ejection of rock pieces, called flyrock, which may result in human injuries, fatalities and property damage.⁶

“The multiple studies reviewed and analyzed concluded that ‘there are major research gaps into the phenomena of flyrock and that this concept is not well understood (Raina, Murthy, and Soni, 2015).”⁷

Van der Walt and Spiteri concluded that “the effect of blast parameters of flyrock is still not fully known or understood,” and that the findings, in part, are “contradictory [p. 712 & 714].”⁸

“...[T]here is no magic technique that eliminates the risk of flyrock, and no matter how controlled our blast is, the best alternative is to prevent, through the identification of risk situations and the implementation of adequate control measures for these situations [i.e., permanent minimum onsite setbacks (excavation limits) and permanent offsite minimum separation distances from sensitive land uses]”⁹

There are several empirical methods for calculating flyrock¹⁰ but none are capable of accurate prediction due to the complexity and difficulty of rock analysis.¹¹

⁴ Bajpayee, T.S., Verakis, H.C. and Lobb, T.E. “An Analysis and Prevention of Flyrock Accidents in Surface Blasting Operations,” *Centers for Disease Control and Prevention*, March 2007. https://www.researchgate.net/publication/265184111_An_Analysis_and_Prevention_of_Flyrock_Accidents_in_Surface_Blasting_Operations.

⁵ *Castonguay Blasting Ltd. v. Ontario (Environment)*, 2013 SCC 52 (CanLII), [2013] 3 SCR 323, <<https://canlii.ca/t/g1038>>, retrieved on 2023-06-02.

⁶ Jamei, M., Hasanipanah, M., Karbasi, M., Ahmadianfar, I. and Taherifar, S. “Prediction of flyrock induced by mine blasting using a novel kernel-based extreme learning machine,” *Journal of Rock Mechanics and Geotechnical Engineering*, Vol. 13, Issue t, December 2021: 1438-1451. <https://www.sciencedirect.com/science/article/pii/S1674775521001189>.

⁷ van der Walt, J. and Spiteri, W. “A conceptual technique to mathematically quantify the trajectory of flyrock,” *Journal of Southern African Institute of Mining and Metallurgy*, 2023, Vol. 123, no. 4: 165-174. <https://issuu.com/saimm/docs/saimm-202304-apr/s/25372330>.

⁸ van der Walt, J. and Spiteri, W., 2020. “A critical analysis of recent research into the prediction of flyrock and related issues resulting from surface blasting activities,” *Journal of the Southern African Institute of Mining and Metallurgy*, vol. 120, no. 12, pp. 701-714. <https://www.saimm.co.za/Journal/v120n12p701.pdf>.

⁹ “Flyrock (part 02 of 03),” *Blasting Trainings LinkedIn*, Aug 26, 2022. <https://www.linkedin.com/pulse/flyrock-part-02-03-blasting-trainings?trk=pulse-article>.

¹⁰ Lwin, M.M. & Aung, Z.M. (2019), “Prediction and Controlling of Flyrock due to Blasting for Kyaukpahto Gold Mine,” *International Journal of Advances in Scientific Research and Engineering*, 5(10), 338-346. <https://ijasre.net/index.php/ijasre/article/view/668>.

¹¹ Balakrishnan, V. and Rai, P. (2021), “An Overview of Flyrock and its Prediction in Surface Mine Blasting using Soft Computing Techniques,” *Recept Tayyip Erdogan University Journal of Science and Engineering*, 2(2) 105-119. <https://dergipark.org.tr/tr/download/article-file/1941187>.

*Flyrock is unpredictable, both in terms of distance and direction.*¹²

*The potentially deadly consequences of flyrock do not decrease with distance, as a 200-gram projectile can be as fatal at 20 metres as it is at 1,000 metres.*¹³

*According to Keith Taylor, General Manager, Austin Powder Company Ltd., “90% of flyrock incidents are ‘unexplainable.’”*¹⁴

*Tim Rath, Green Mountain Explosives, the blasting expert acting on behalf of Rivers’ Quarry application testified that he could not guarantee that flyrock will not leave the Rivers Quarry regardless of what precautions are taken to minimize the risk.*¹⁵

*“The phenomena of flyrock are always uncontrolled and can never be brought down to zero [p. 1].”*¹⁶

*“There isn’t a company that could stand up here and say they don’t have flyrock,” said Shawn McGoldrick, of McGoldrick Brothers Blasting Services.*¹⁷

*Accidental flyrock in blasting operations has a major impact on the external environment...due to the hazards involved and is more significant than vibrations or airblast...[E]ven if it is normal practice in these zones to take into account the impact of possible vibrations and even the effects of airblast when modeling the project, flyrock risks are not dealt with in initial studies, other than by way of integrating general safety distances. These risks are only sometimes taken into account much later in the operation and most often following an accident or significant flyrock being recorded externally [off-site] [p. 549].*¹⁸

¹² Rathore, S.S. and Jain, E.S.C., “Studies on flyrock at soapstone quarry for safe working,” 2007 Vienna Conference Proceedings 2007, European Federation of Explosives Engineers. <https://www.efee.eu/wp-content/uploads/2016/04/7-Health-Safety-and-Environment.pdf>.

¹³ Sauvage, A.C., “Flyrock: French Experience,” (2017) 61 SAFEX Newsletter. <https://ap3e.pt/wp-content/uploads/2021/03/2017-2-Newsletter-61.pdf>.

¹⁴ MOE 2009 investigation Case File Number: 2283-83MN69 of two flyrock incidents at Pakenham Quarry, and investigating explosives engineer recommended 500-metre onsite setback for all future blasts. (detonation of explosives).

¹⁵ http://www.killthealbionquarry.org/flyrock_danger.pdf. (website no longer active)

¹⁶ Trivedi, R., Singh, T.N. and Raina, A.K. “Prediction of blast-induced flyrock in Indian limestone mines using neural networks,” *Journal of Rock Mechanics and Geotechnical Engineering*, (2014): 1-8. 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.

¹⁷ Hartwell, Michael. “Busque quarry stonewalled at town meeting,” *Lakes Region Weekly*, November 16, 2006, Updated March 10, 2016. <https://www.pressherald.com/2006/11/16/busque-quarry-stonewalled-at-town-meeting/>.

¹⁸ Blanchier, A. (2012). Quantification of the levels of risk of flyrock. The 10th International Symposium on Rock Fragmentation by Blasting (Fragblast 10), Leiden, p. 549-553.

The “Running List” of Flyrock Incidents

Described below are details of a “running list” of *flyrock* incidents discovered from a variety of sources on the internet, which have been documented as of June 2023:

- *Flyrock 196*: On July 13, 1997, during the demolition of a hospital in Camberra, Australia, billed as a family event, included an exclusion zone of 200 yards (183 metres) to protect the spectators. The detonation of the explosives sent *flying debris* that struck and killed a 12-year-old girl standing in a park about 400 yards (366 metres) across a lake from the hospital. Witnesses said debris was launched more than 500 yards (>457 metres) from the blast site.¹⁹
- *Flyrock 197*: On June 7, 2022, blasting rock to make way for a residential subdivision in Hendersonville, Tennessee, launched *flyrock debris* that penetrated homes in a nearby Stonecrest subdivision.²⁰ Homeowner Seeley found a 5-pound rock in his backyard; which is located 1,500 feet (457 metres) from the blast site; another homeowner reported a 10- to 15-pound (4.5- to 6.8-kilogram) rock penetrating the ceiling of her home; and another homeowner discovered a rock had penetrated her garage and damaged her mower.²¹
- *Flyrock 198*: On November 24, 2020, blasting on a road project in the Chesapeake area of Lawrence County, Ohio, to remove rock launched *flyrock debris* across Highway 52 into the Sunnybrook subdivision. Some of the rocks hit and damaged homes. A fragment from a rock that hit the ground and shattered struck the leg of a neighbour.²²
- *Flyrock 199*: On October 4, 2022, blasting rock at a new site for the Louisville VA Medical Center launched *flyrock debris* onto Watterson Expressway (I-264) causing drivers to swerve to avoid being hit. Flyrock debris, characterized as a “meteor shower,” littered the streets in the neighborhoods adjacent to the construction site and several homes had rocks in their yards, driveways and gutters, and some houses were pierced and damaged by rocks.(As of Jan 23, 2023, repairs had still not been undertaken.)²³

¹⁹ “Australian demolition kills young onlooker,” *World News*, July 13, 1997. <http://www.cnn.com/WORLD/9707/13/australia.demo/>.

²⁰ “Hendersonville homes pelted with rock damage after blasting,” News Channel 5, YouTube, June 7, 2022. <https://www.youtube.com/watch?v=NFb9FzQ8Jkk>.

²¹ Lee, Tina. “Construction Blast sends large rocks sailing in Stonecrest,” *Hendersonville Standard*, June 8, 2022. https://www.hendersonvillestandard.com/news/construction-blast-sends-large-rocks-sailing-in-stonecrest/article_aa882604-e6a5-11ec-b2dc-cb5e76379dc3.html.

²² Colegrove, Andrew. “Homes damaged by boulder blasting road project,” *WSAZ News Channel 3*, November 24, 2020. <https://www.wsaz.com/2020/11/24/homes-damaged-by-boulder-blasting-road-project-in-ohio/>.

²³ Vogt, Dustin. “Blasting at VA medical center halted after ‘unforeseen incident’ with falling rocks,” *Wave 3*, Oct. 4, 2022. <https://www.wave3.com/2022/10/04/blasting-va-medical-center-site-halted-after-unforeseen-incident-with-falling-rocks/>, An investigation concluded that the flyrock incident “was the result of an unintended simultaneous detonation of several explosive charges [went off at the same time] which were designed to detonate on a precisely timed sequence.”

- *Flyrock 200*: On February 8, 2023, a single-hole blast at the Williamson County rock quarry (302 Beasley Dr. Franklin, Tennessee) launched *flyrock debris* as far as 2,000 feet (610 metres) from the blast site that caused road damage, damaged several vehicles and that pelted the Williamson County Election Commission building, which was occupied at the time of the blast. In this so-called “routine” blast, the hole did not contain the explosive slurry as planned; instead, it seeped into the ground below and more explosives were loaded into the cavity, and when detonated the hole blew out causing airblast and flyrock.²⁴
- *Flyrock 201*: On February 15, 2023, a blast at the Mayali stone quarry in Jashpur district of Chhattisgarh, India, launched *flyrock debris* including a large boulder that struck 18-year-old student Kesari Bai, killing her instantly, at a distance of over one kilometer (>1,000 metres) from the quarry while on her way to a park with her friend. She died of severe head injury after profusely bleeding while her friend had a narrow escape.²⁵
- *Flyrock 202*: On October 13, 2006, a blast at a quarry in Far North District, New Zealand, launched *flyrock debris* that damaged a hydro transmission line leaving 10,000 properties north of the Mangamuka Ranges without electricity from 7am to mid-afternoon. Homes, hospitals, emergency services, businesses and farms were all without electricity during that period.²⁶
- *Flyrock 203*: In March 1995, while constructing roadway improvements in Macon County, Tennessee, Jones Bros. blasted several large rocks, which “blew out” the top of a large boulder that launched *flyrock debris* onto nearby property, including the Bohanons’ home located 600 feet (183 metres) from the blast site. The flyrock debris damaged the roof and ceiling washroom of the Bohanons’ home.²⁷
- *Flyrock 204*: On August 11, 2014, blasting on Big Nickel Mine Road, Sudbury, undertaken by Rock Breakers launched golf ball-sized *flyrock debris* onto nearby Sandra Boulevard, Westview Drive and Buchanan Street, and that shattered two windows and punched a hole in the shed of a homeowner’s property on Sandra

<https://www.lrl.usace.army.mil/Media/News-Releases/Article/3271969/investigations-into-october-blasting-incident-complete/>.

²⁴ “Tuesday’s explosion came from county’s rock quarry; no reported injuries,” *Williamson Herald*, Feb 9, 2023. https://www.williamsonherald.com/news/local_news/afternoon-explosion-at-rock-quarry-felt-throughout-franklin-beyond/article_009e1fa4-a806-11ed-9456-ff654fa9034c.html.

²⁵ “18-year-old girl dies after getting hit by flyrock of mine blast in Jashpur district of Chhattisgarh,” *The Times of India*, February 17, 2023. <https://timesofindia.indiatimes.com/city/raipur/18-year-old-girl-dies-after-getting-hit-by-flyrock-of-mine-blast-in-jashpur-district-of-chhattisgarh/articleshow/97996266.cms>.

²⁶ Laird, Lindy. “Quarry blast cuts power,” *Northern Advocate*, October 16, 2006. <https://www.nzherald.co.nz/northern-advocate/news/quarry-blast-cuts-power/NIKAS2EQXP5N4KLS4IGYL54KD4/>.

²⁷ *Steven Teddy Bohanon, et al., v. Jones Bros., Inc.*, M1998-00954-COA-R3-CV (Tenn.App. 2-22-2002). <https://www.tncourts.gov/sites/default/files/OPINIONS/TCA/PDF/021/BohanonST.pdf>.

Boulevard. Rock Breakers characterized “the blast...as no larger than other blast and that the damage was ‘unforeseen.’”²⁸

- *Flyrock 205*: On March 12, 1991, a blast at the Martinsville stone quarry in Collinsville, Virginia, launched *flyrock debris*, which showered and damaged several homes and a vehicle owned by Mrs. Martin. In one instance the rock blasted a hole 6 feet in diameter in the brick wall of the home (and destroyed some house contents) of James Doss, who was standing within six feet of the boulder, and two other rocks knocked holes in Doss’ garage roof and wall. At least two other homes were struck by flyrock debris, at a distance of about a half-mile (805 metres) from the quarry.²⁹
- *Flyrock 206*: On May 20, 2019, a blast at a rock quarry in Cannon County, Tennessee, launched *flyrock debris* that travelled across both lanes of John Bragg Highway and struck a moving vehicle and caused other additional damage, including striking a home in a nearby subdivision.³⁰
- *Flyrock 207*: On December 7, 2010, a blast at the Mercer Stone Co. quarry on Burgin Road (Ky. 152) in Mercer County, Kentucky, launched *flyrock debris* that sent a rock through the windshield of a pickup truck travelling on the U.S. 127 Bypass near Harrodsburg, The driver of the truck was fortunate not to have been fatally injured.³¹
- *Flyrock 208*: On February 14, 2023, a blast at a construction site for an apartment complex in Staunton, Virginia, launched *flyrock debris* that landed on a nearby property on Moore Street. Randy Young, the homeowner, watched the blast and “had to run for cover” to avoid being struck by the flyrock debris.³²
- *Flyrock 209*: On August 10, 2017, a blast at a quarry in Demodara, Sri Lanka, launched *flyrock debris* (shrapnel) that struck 24-year-old Charlie Rozilbo on his hand as he was passing nearby on his way to visit a tea factory. He was admitted to Badulla General Hospital, where his injured hand had to be operated on.³³
- *Flyrock 210*: On May 25, 2023, a blast at a stone quarry in Kolar Taluk, India, launched *flyrock debris* that struck 28-year-old quarry worker Somu Jadhav at a

²⁸ Byrne, Ryan. “Blast pelts Sudbury neighbourhood with rocks,” *Sudbury Star*, Aug 16, 2014. <https://www.thesudburystar.com/2014/08/16/blast-pelts-sudbury-neighbourhood-with-rocks>.

²⁹ “Rocks from blast damage houses,” *The Roanoke Times*, March 14, 1991. <https://scholar.lib.vt.edu/VA-news/ROA-Times/issues/1991/rt9103/910314/03140191.htm>.

³⁰ Breslow, Josh. “Cannon County rock quarry shut down amid state investigation,” *WKRN.COM*, May 22, 2019. <https://www.wkrn.com/news/cannon-county-rock-quarry-shut-down-amid-state-investigation/>.

³¹ “Blasts at Mercer quarry sends rock into windshield,” *Lexington Herald Leader*, December 7, 2010. <https://www.kentucky.com/latest-news/article44067387.html>.

³² Ganesh, Akhil, “Staunton residents concerned over blasting for Middlebrook Trace apartment complex,” *News Leader*, March 3, 2023. <https://www.newsleader.com/story/news/2023/03/02/staunton-residents-concerned-over-blasting-for-middlebrook-trace-apartment-complex/69964510007/>.

³³ Fonseka, Piyumi. “French tourist injured by shrapnel from rock quarry,” *Daily Mirror*, August 11, 2017, <https://www.dailymirror.lk/article/French-tourist-injured-by-shrapnel-from-rock-quarry-134545.html>.

distance of 600 metres from the blast site, who succumbed to his injuries the next day at MEG Hospital in Hosakote. A second quarry worker, Gopi, was injured and taken to a hospital in Kolar. The quarry operators made attempts to destroy evidence. Six people, including the quarry owner, quarry operator and the suppliers of the explosives, were arrested.³⁴

- *Flyrock 211*: On December 24, 2005, a blast at Masslite Quarry, Plainville, Massachusetts, launched *flyrock debris* that penetrated the roof of Sharon Friedman's garage studio on High Street amidst a spray of debris and damaged furniture about 1,100 feet (335 metres) from the blast site. The rock in Friedman's studio, weighing about 150 pounds (68 kilograms), was one of three found on her property.³⁵
- *Flyrock 212*: On July 13, 2005, a blast at Hunts Branch Freeburn Mine, a surface coal mine located in Pike County, Kentucky, launched *flyrock debris* that struck and injured quarry employee Travis Tackett, and that damaged a blue supply truck, a yellow loader and a white pickup truck. Travis Tackett suffered a compound fracture after being struck in the leg by flyrock. Bellamy, a mining engineer who works for Mine Safety and Health Administration (MSHA) cautioned, "[E]very shot...is not going to go off exactly as...intended."³⁶

Previously, a total of approximately 195 flyrock incidents had been discovered and analyzed.³⁷ Of the 195 flyrock incidents discovered, 33 resulted in death, indicating an overall kill rate of 16.9%, and 40 people were injured in the same 33 flyrock incidents. An additional 17 flyrock incidents have been added to the "running list" of flyrock incidents bringing the total to 212. Of these additional 17 flyrock incidents, 3 people were killed, and 1 person injured, indicating a kill rate of 17.6% (3 ÷ 17).

- Of the 212 flyrock incidents documented, 36 resulted in death (children, men and women) from being struck by flyrock debris, reflecting a "kill" rate of 17.0% (36 ÷ 212), and 41 more people were injured in the same 36 flyrock incidents.

³⁴ "Worker Killed, another injured in stone quarry blast in Kolar," *DHNS, Kolar*, May 26, 2023. <https://www.deccanherald.com/state/karnataka-districts/worker-killed-another-injured-in-stone-quarry-blast-in-kolar-1221980.html>.

³⁵ McCarron, Heather, "Milford company probing incident that sent rock into home," *Milford Daily News*, December 29, 2005. <https://www.milforddailynews.com/story/news/2005/12/29/milford-company-probing-incident-that/41387771007/>.

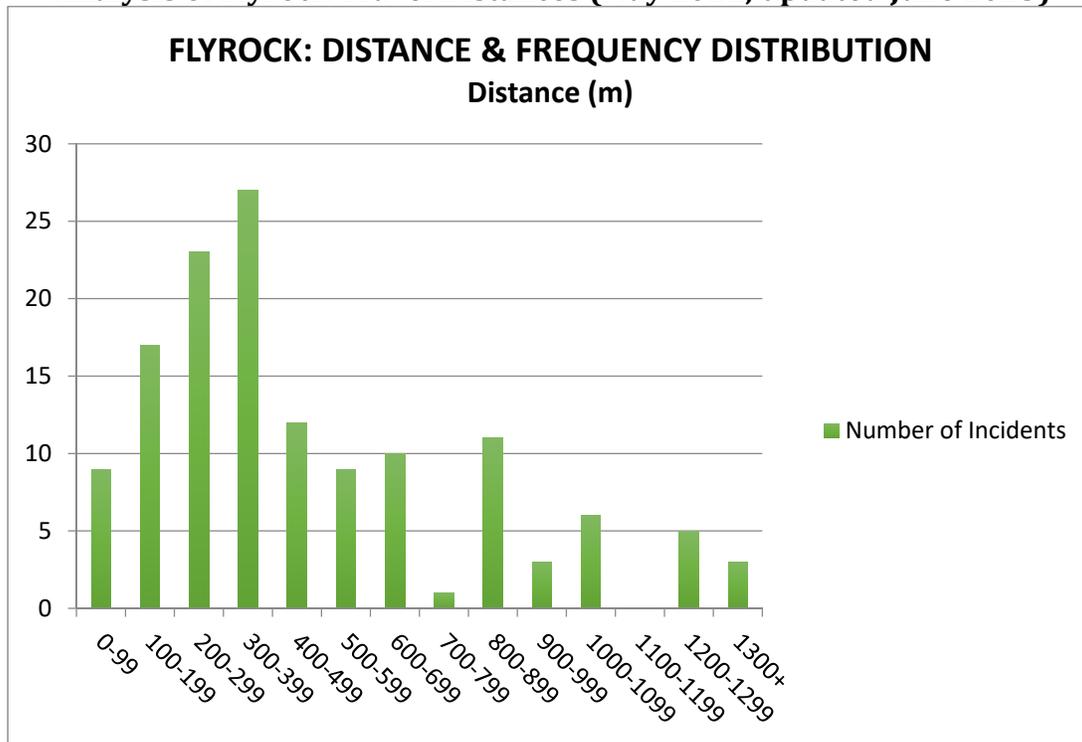
³⁶ Federal Mine Safety and Health Review Commission, Civil Penalty Proceeding, June 1, 2007. <https://www.fmshr.gov/decisions/alj/kt2006-120.pdf>.

³⁷ Sevelka, T., (2022) "Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required," *Grassroots Journal of Natural Resources*, 5(4): 66-98. <https://grassrootsjournals.org/gjnr/nr-05-04-05-sevelka-m00318.pdf>.

Updated Flyrock Distances Where Distance From Blast Site Known (June 2013)

A non-theoretical *quantitative* study of actual distances that flyrock has been launched from a blast site was undertaken by Sevelka (May 2021)³⁸ and included in that analysis are 92 incidents of flyrock. Since then, more incidents of flyrock have been documented, expanding the data set from 92 to 136 incidents of flyrock (June 2023). Where flyrock debris has been launched over a large area or in more than one direction, only the furthest distance of the flyrock from the blast site is recorded, summarized and arrayed in the following bar chart.

Analysis of Flyrock Travel Distances (May 2021; updated June 2023)



- An analysis of 136 *flyrock* incidents, where the distance from the blast site is known, indicate that 94% (128) of the *flyrock* incidents occurred within 1,099 metres, and 98% (133) occurred within 1,299 metres.

The number of *flyrock* incidents within each interval, starting at between 0-99 metres, and the average distance travelled within each interval are summarized as follows:

³⁸ Sevelka, T., (2022) "Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required," *Grassroots Journal of Natural Resources*, 5(4): 66-98. <https://grassrootsjournals.org/gjnr/nr-05-04-05-sevelka-m00318.pdf>.

Metres	0-99	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1199	1200-1299	1300+
Incidents	9	17	23	27	12	9	10	1	11	3	6	0	5	3
Cumulative	-	26	49	76	88	97	107	108	119	122	128	128	133	136
Average (m)	59	148	240	329	440	512	616	700	803	916	1015	-	1225	2307
% of Total	7%	13%	17%	20%	9%	7%	7%	1%	8%	2%	4%	0%	4%	2%
Cumulative %	-	19%	36%	56%	65%	71%	79%	79%	88%	90%	94%	94%	98%	100%

- At 90%, of the 136 *flyrock* incidents, 122 *flyrock* incidents in ascending order reached a distance up to the 900 – 999 metre interval, and, at 94%, which accounts for the first 128 *flyrock* incidents in ascending order, *flyrock* reached a distance up to the 1000 – 1099 metre interval.
- On the basis of the this updated study of *flyrock* incidents (June 2023), the designated blast area (onsite safety zone) would have to be approximately 1,000 metres to effectively prevent 94% of *flyrock* incidents from leaving the boundaries of a blasting quarry site, equivalent to a 1,000-metre setback.

Trespass of Land – Flyrock and Vibration

The Factum of the Interveners³⁹ in the *Castonguay* case before the Supreme Court of Canada, (2013), which involved a *flyrock* incident, describe *trespass* as follows:

Trespass is the intentional physical invasion of property by people or objects, however minute the invasion, without the consent of the owner of occupant. Liability in trespass does not depend on proof of damages. To deposit a foreign substance such as water on the property of another and, in so doing, disturb that person's possession of property, however slight the disturbance, constitutes trespass, regardless of whether the substance is toxic or non-toxic. [citations omitted]

In *Enos Coal Mine v. Schuchart et al.*, (2019),⁴⁰ the Indiana Supreme Court ruled there is no logical reason not to extend *strict liability* for property damage from *vibrations* simply because there is no physical trespass as in falling debris [*flyrock*] from an explosion on nearby land. The court ruled that the common law principle of liability in *trespass* applies equally where damage is caused only by *vibration*, commenting by way of analogy, as follows:

In these days of nuclear explosions, the breaking of sound barriers by airplanes and missiles, violent explosions from artillery and gunnery practice (to mention but a few of the advances of science), nearby buildings and property can be shattered or destroyed as effectively as by an earth quake without any physical invasion of the property.

The United States Supreme Court has recognized these modern problems in holding that property owners are entitled to compensation for deterioration in property values caused by noise and vibration of jet planes in the use of air space near an airport. Griggs v. Allegheny County (1962), 369 U.S. 84, 82 S.Ct. 531, 7 L.Ed.2d 585.

³⁹ <https://cela.ca/wp-content/uploads/2019/07/Castonguay-SCC-Factum.pdf>.

⁴⁰ *Enos Coal Mining Company v. Schuchart et al.*, 243 Ind. 692 (1963) 188 N.E.2d 406, https://scholar.google.com/scholar_case?case=5259210695212382453&q=%22a+little+damage+is+reasonable%22&hl=en&as_sdt=2006.

Nuisance and The Rule of Rylands (Strict Liability)

According to Grant,⁴¹ the tort of *nuisance* is similar to the tort of *trespass*, to the extent that it is for the protection of a property owner's "use and enjoyment" of land, and can apply to all-manner of activities conducted by a nearby quarry blasting operation that have the potential for *adverse effects*.

Nuisance focuses on the effect of certain activities on neighbouring property holders, the nature of the interest invaded, and the extent of the invasion, rather than on the tortfeasor (as in negligence). The essence of the tort of private nuisance is that the tortfeasor has unreasonably and substantially interfered with another's reasonable use and enjoyment of his or her land. Interference can be separated into two categories: material physical damage, and interference with enjoyment of land.

It is not necessarily a defense to nuisance to show that all possible care has been taken in carrying on the activity which caused the invasion.

In determining whether there has been an unreasonable interference with the use and enjoyment of the plaintiff's land, the court balances the gravity of the harm caused against the utility of the defendant's conduct in all the circumstances. The court also measures the harm in the context of factors like the character of the locale, and whether or not the plaintiff has an abnormal sensitivity.⁴²

The Rylands v. Fletcher rule is one of the situations at common law where there can be tort liability for unintended and non-negligent harm. The rule states that "a person who for his own purposes brings on his lands and collects and keeps there anything likely to do mischief if it escapes, must keep it in at his peril, and if he does not do so, is prima facie answerable for all the damage which is the natural consequence of its escape."

The three things necessary to succeed in an action under the rule in *Rylands v. Fletcher* (strict liability) are:

1. *The defendant brought something capable of causing harm onto his or her land.*
2. *The defendant made use of the thing for his or her own profit or benefit.*
3. *The use of the thing, in addition to being dangerous, was unusual or non-natural [p. 339].⁴³*

Conclusion

As this paper illustrates, Flyrock is an ever-present danger whenever blasting to break rock is conducted. Both onsite quarry employees and people (children, women and men) who live, work, shop and play offsite near an operational blasting quarry are vulnerable to the potentially deadly consequences of flyrock. Flyrock is an inevitable by-product of blasting rock, and can never be brought down to "zero." Mandatory minimum setbacks (extraction limit) imposed on the lands stated for aggregate extraction coupled with a mandatory separation distance between the boundaries of a proposed quarry site and sensitive land

⁴¹ Adam Grant, "Making Use of Unusual Torts in Subrogation," July 2017, https://mccagueborlack.com/emails/articles/unusual-torts.html?utm_source=Mondaq&utm_medium=syndication&utm_campaign=LinkedIn-integration.

⁴² *Antrim Truck Centre Ltd. v. Ontario (Transportation)*, 2013 SC 13, and Allen M. Linden & Bruce Feldthusen, *Canadian Tort Law*, 10th ed (Toronto: LexisNexis Canada, 2015) at 609-621. *Antrim Truck Centre Ltd. v. Ontario (Transportation)*, 2013 SCC 13 (CanLII), [2013] 1 SCR 594, <<https://canlii.ca/t/fwdn1>>, retrieved on 2023-06-18.

⁴³ C. A. MacLean, L. M. Olivo and J. Fitzgerald, *Contract and Tort Law*, Second Edition, ©2018, Emond, Toronto, Canada.

uses are the only effective means of avoiding or mitigating damage to personal and real property, and the potentially deadly consequences of flyrock. No quarry operation has the right to the free use of nearby land by interfering with the *use* and *enjoyment* of public or private third-party property. The quantitative analysis of the travel distances of 136 flyrock incidents from a blast site presented in this paper provide municipalities and its Land Use Planners with a means of avoiding land use conflicts and mitigating the potentially deadly consequences of flyrock through the enactment of permanent minimum onsite setbacks (extraction limits) combined with offsite permanent minimum separation distances from sensitive land uses.