GRASSROOTS JOURNALS

JOURNAL OF ENVIRONMENTAL LAW & POLICY | 03(02) AUGUST 2023
Published by The Grassroots Institute, in partnership with Yaroslav Mudriy National Law University of Ukraine, and in collaboration with Northern Institute of Minority & Environmental Law, University of Lapland. Website: https://grassrootsjournals.org/jelp

ISSN 2564-016X | August 2023

M – 00348 | Analytical Article | Open Access

FLYROCK THROW CALCULATIONS UNSCIENTIFIC AND UNRELIABLE – THE "HITS" JUST KEEP ON COMING

Tony Sevelka
International Valuation Consultants Inc., Suite 38, Matheson Mews, 2601 Matheson Boulevard East, Mississauga, Ontario L4W 5A8 Canada.
E-mail: info@intval.com | ORCID: https://orcid.org/0000-0002-2210-421X

Received: 07 June 2023 | **Accepted:** 30 June 2023 | **Published:** 27 August 2023

ABSTRACT

Flyrock is the dirty little secret of the aggregate industry and its explosives engineers, and they have been remarkably successful in concealing the potentially deadly consequences of flyrock from the public, while continuing to engage in reckless blasting practices based on theoretical guesswork rather than proven practical land use planning safeguards such as permanent (fixed) onsite setbacks (excavation limits) coupled with permanent offsite separation distances from existing and potential future sensitive land uses. Flyrock is an unavoidable by-product of blasting rock, and has the potential to damage personal or real property, injure, permanently disable or kill humans and non-humans, both onsite and offsite. Flyrock, along with other adverse effects such as vibrations, that leaves the boundaries of an aggregate operation, constitutes *nuisance* and *trespass*, and damage or injury caused by detonation of explosives, should be held to *strict liability*. Implementing proactive and forward-looking land use policies that safeguard existing and envisioned sensitive land uses from the potentially deadly consequences of detonation of explosives in aggregate extraction is the most effective way to protect the long-term health, safety and welfare of existing and future generations, and to avoid interfering with the use and enjoyment of third-party real property.

Keywords: Flyrock; Liability; Mining; Explosions; Environmental impacts; Legislation

Editor-in-Chief: Prof. Dr. Kamrul Hossain | *Deputy Editors-in-Chief:* Dr. Evgeniya Kopitsa, Prof. Dr. Ngozi Finette Unuigbe | *Executive Editor:* Dr. Hasrat Arjjumend

How to cite this paper: Tony Sevelka, 'Flyrock Throw Calculations Unscientific and Unreliable – The "Hits" Just Keep on Coming' (2023) 03 (02) Journal of Environmental Law & Policy 1-26 <https://doi.org/10.33002/jelp03.02.01>

Copyright © 2023 by author(s). This work is licensed under the Creative Commons Attribution International License (CC BY 4.0). http://creativecommons.org/licenses/by/4.0/

Open Access

Flyrock Throw Calculations Unscientific and Unreliable – The "Hits" Just Keep on Coming

1. INTRODUCTION

The aggregate extraction industry and 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 (MNRF) has never undertaken a quantitative study of flyrock incidents, even though flyrock is the most dangerous aspect of blasting rock. The different formulas used to calculate the "throw" distance of flyrock are unscientific, unreliable and self-serving. 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 both onsite and offsite. Flyrock launched offsite onto publicly- or privately-owned third-party property constitutes *nuisance* and *trespass.* Blasting (detonation of explosives) to break rock is an ultra-hazardous or inherently dangerous activity, which by its nature, cannot avoid the likelihood of damaging property or harming human and non-human life.

In *Darney v. Dragon Products Company, LLC, Dist. Court*[1], District Maine (2011), the court had to say in its analysis of the dangers posed by blasting explosives:

> *"The Court has little difficulty agreeing with the Darneys that blasting poses a high degree of risk of some harm to both persons and property. Even defense expert Mr. McKown specifically stated on direct that "Yes, I believe that the handling of explosives is inherently dangerous". (Tr. Vol. IV at 856.) Indeed, the Bureau of Mines conducted extensive studies on blasting done near residential structures, which demonstrated quite conclusively that blasting has the potential to cause damage to buildings from fly rock, ground vibration, and airblast. Similarly, given the extensive best practices recommended by the BOM by those engaging in quarrying activities, and the rigor with which the State of Maine oversees such activities, the Court has little difficulty that any such resulting harm has the potential to be great. In short, in applying these first two factors, the Court agrees with the Dyer Court that "blasting is inherently dangerous." Dyer, 984 A.2d at 216 (citing Maravell, 914 A.2d at 714)". [emphasis added]*

Referring above, this article presents a "running list" of documented flyrock incidents as a continuation of previous research addressing flyrock, and should be read in conjunction with another article, "*Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required*" (Sevelka, 2022).[2]

[1] https://casetext.com/case/darney-v-dragon-products-company-2

[2] Sevelka, T., 'Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required', (2022) 5(4) Grassroots Journal of Natural Resources 66-98. <https://doi.org/10.33002/nr2581.6853.050405>.

2. CONSEQUENCES OF BLASTING ROCK WITHIN REGULATORY LIMITS UNCONTROLLABLE

The term "controlled blast" is often used by the aggregate industry and explosive engineers to misleadingly imply that blasting (detonation of explosives) within regulatory limits cannot possibly cause damage to structures or buildings, or worse yet kill someone.

In *Hutchins v. Mutual of Enumclaw Insurance Co.,* (1973),[3] blasting was found by the Supreme Court of Oregon to be the cause of damage to two properties located 4,000 feet (1,219 metres) from the blast site. Between October 25 and October 31, 1968, four thousand four hundred and thirty (4,430 detonations), 7,000 pounds (3,175 kg) and 8,200 pounds (3,629 kg) of explosives were detonated, each with a series of seven delays of one hundredths of a second (10 milliseconds) delay. One of the blasts damaged two properties, terrified the homeowners, and spooked two horses:

> *"On or about October 30, 1968, plaintiffs' home was shaken by an explosion. Mr. Hutchins was thrown to the floor and Mrs. Hutchins ran outside the house. They thought something had exploded in the basement. After the explosion, plaintiffs discovered plaster dust and pieces of plaster on the floor of their home and cracks in the wall of their dining room and living room. The east basement wall of the house was "bowed" out of line; masonry at the front of the house had been cracked and loosened, and moisture problems occurred in their basement."*
>
> *"[A neighbour, Mr. Bird, testified that]…all of a sudden the house just cracked, and there was just kind of a big concussion…It scared me, and I run outside and – to see what happened. And my horses were both trying to get out of the barn at the same time. It spooked them. They run up in the pasture like crazy….Immediately after the explosion he discovered plaster dust over his davenport and a crack in the ceiling of his home…"*

The Supreme Court of Oregon rejected the defendant's argument as presented by Mr. Cooper, an explosives engineer, "that the plaintiffs' [homeowners'] testimony should be disregarded because it transcends the laws of nature and it was inherently physically impossible for the blasting to have caused plaintiffs' damage." But, the explosives engineer conceded "it's possible… [that the October 30, 1968, blast] to [have] cause[d] some damage." The explosives engineer also conceded that:

> *"[T]here is no certainty in determining the areas which may be affected by blasting since the consequences of an explosion are dependent upon many variables. Mr. Cooper described the three different types of reaction caused by such blasting, ground shock, air blast and reactive air wave, and in his opinion you cannot predict with utter certainty the consequences of a blast, that temperature, wind velocity, humidity, and components of the earth material make a difference in the transfer of the shock and the distance it travels."*

[3] *Hutchins v. Mutual of Enumclaw Insurance Co.*, 516 P.2d 1273 (1973) Or: Supreme Court. <https://casetext.com/case/hutchkins-v-mutual-of-enumclaw-ins>, accessed 10 August 2023.

2.1 Calculated Flyrock "Throw" Distances Unscientific and Unreliable

According to Shi et al. (2013),[4] because of the complexity of the issues surrounding flyrock, there are no reliable formulas to accurately predict the distance that flyrock will launch from a blast site.

> *"With so many complex factors of blasting flyrock, there is no critical formula for prediction [of] the flying distance of blasting flyrock…[as] adapted by most…scholars. Widely existing influential prediction formulas are mainly aimed at ordinary blasting technology, using the statistical law or mechanics analysis to get the prediction. The calculated data for flyrock distance are different distinctly. Predicted values are different largely between various formulas."*

Similar findings as to the unreliability of predicting flyrock throw distance have been reached by van der Walt (2020)[5] and Szendrei (2022)[6]:

> *"The testing methodologies used to measure the actual flyrock distance are not scientific and are highly dependent on the scrutiny of the researcher (*van der Walt, 2020*)."*
>
> *"It is evident that there is no proven and reliable method for predicting flyrock velocity and throw range (*Szendrei, 2022*)."*

3. CHARACTERISTICS OF FLYROCK – AN UNAVOIDABLE BY-PRODUCT OF ROCK BLASTING

Flyrock is the ultimate *adverse effect*, and is also the most dangerous aspect of blasting (detonation of explosives) to break rock. Blasting is an *ultra-hazardous* activity, and as blasting within regulatory limits cannot prevent flyrock, the activity is held to *strict liability* or *The Rule of Rylands*[7] 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 article.

"Flyrock" means rock that is thrown through the air as a result of blasting [i.e., detonation of explosives].[8]

- *"Flyrock can be gravel, rocks, tree trunks, construction materials, mud – even water."*[9]

---

4 Shi, J., An, H. and Wu, C., 'Regression and Fitting Analysis of Flyrock Prediction Formulae for Loosening Blasting' (2013) 405-408 Applied Mechanics and Materials 2346-2350.

5 van der Walt, J., 'A Critical Analysis of Recent Research into the Prediction of Flyrock and Related Issues Resulting from Surface Blasting Activities' (2020) 120 (12) J. S. Afr. Inst. Min. Metall. <http://dx.doi.org/10.17159/2411-9717/1103/2020>.

6 Szendrei, T. and Tose, S., 'Flyrock in surface mining – Limitations of current predictive models and a better alternative through modelling the aerodynamics of flyrock trajectory' (2022) 122 (12) J. S. Afr. Inst. Min. Metall., <https://dx.doi.org/10.17159/2411-9717/1873/2022>.

7 *Rylands v. Fletcher*, (1868) LR 3 HL 330.

8 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.

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

- *"Flyrock comes in different sizes and shapes, ranging in mass from [a] few ounces to several tons. Persson et al. [1994] referenced flyrock weighing approximately three tons thrown to a distance of 980 ft. [299 metres]."*[10]
- *"Flyrock from surface blasting operations has caused serious injury and death to employees and other persons."*[11]
- *[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).*[12]
- *"…[F]lyrock may be the greatest threat related to working with explosives, and it's something that those involved in the blasting situation may not realize. They may be primarily concerned about staying out of the blast radius and thereby avoiding being damaged by concussive force or ground vibrations, not realizing that flyrock may create a much greater danger….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 debris."*[13]
- *"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."*[14]

---

[10] 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>, accessed 10 August 2023.

[11] Ibid

[12] *Castonguay Blasting Ltd. v. Ontario (Environment)*, 2013 SCC 52 (CanLII), [2013] 3 SCR 323, <https://canlii.ca/t/g1038>, accessed 02 June 2023.

[13] T.M. International LLC, "Preventing and Controlling Flyrock," *T.M. International, LLC*, 2001, <https://www.tmi2001.com/blog/preventing-controlling-flyrock>, accessed 10 August 2023.

[14] 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" (2021) 13 (1) Journal of Rock Mechanics and Geotechnical Engineering 1438-1451. <https://doi.org/10.1016/j.jrmge.2021.07.007>.

- *"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).'*[15]
- *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]."*[16]
- *"…[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]"*[17]
- *There are several empirical methods for calculating flyrock*[18] *but none are capable of accurate prediction due to the complexity and difficulty of rock analysis.*[19]
- *Flyrock is unpredictable, "both in terms of distance and direction."*[20]
- *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."*[21]
- *According to Keith Taylor, General Manager, Austin Powder Company Ltd., "90% of flyrock incidents are 'unexplainable.'"*[22]
- *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.*[23]

---

[15] van der Walt, J. and Spiteri, W., "A conceptual technique to mathematically quantify the trajectory of flyrock" (2023) 123 (4) Journal of Southern African Institute of Mining and Metallurgy165-174. <https://issuu.com/saimm/docs/saimm-202304-apr/s/25372330>, accessed 10 August 2023.

[16] van der Walt, J. and Spiteri, W., "A critical analysis of recent research into the prediction of flyrock and related issues resulting from surface blasting activities" (2020) 120 (12) Journal of the Southern African Institute of Mining and Metallurgy 701-714. <https://www.saimm.co.za/Journal/v120n12p701.pdf> accessed 10 August 2023.

[17] Rock Blasting, "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>.

[18] Lwin, M.M. & Aung, Z.M., "Prediction and Controlling of Flyrock due to Blasting for Kyaukpahto Gold Mine," (2019) 5 (10) International Journal of Advances in Scientific Research and Engineering 338-346. <https://doi.org/10.31695/IJASRE.2019.33574>.

[19] Balakrishnan, V. and Rai, P., "An Overview of Flyrock and its Prediction in Surface Mine Blasting using Soft Computing Techniques," (2021) 2 (2) Recept Tayyip Erdogan University Journal of Science and Engineering 105-119. <https://dergipark.org.tr/tr/download/article-file/1941187>, accessed 10 August 2023.

[20] Rathore, S.S. and Jain, E.S.C., "Studies on flyrock at soapstone quarry for safe working," (2007) Vienna Conference Proceedings, European Federation of Explosives Engineers, <https://www.efee.eu/wp-content/uploads/2016/04/7-Health-Safety-and-Environment.pdf>, accessed 10 August 2023.

[21] Sauvage, A.C., "Flyrock: French Experience," (2017) 61 SAFEX Newsletter, <https://ap3e.pt/wp-content/uploads/2021/03/2017-2-Newsletter-61.pdf>, accessed 10 August 2023.

[22] 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).

[23] <http://www.killthealbionquarry.org/flyrock_danger.pdf>, accessed 10 August 2023.

- *"The phenomena of flyrock are always uncontrolled and can never be brought down to zero [p. 1]."*[24]
- *"Anyone with experience in surface mining has experienced flyrock issues. And of course seeing a piece of broken drill still sticking out of a roof a long way from a blast can be disquieting. Or finding a small chunk of rock on a roof or in a yard miles away happens all too frequently."*[25]
- *"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.*[26]
- *"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]."*[27]

4. "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 August 2023:

- *Flyrock 196:* On July 13, 1997, during the demolition of a hospital in Canberra, 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* at subsonic speed that struck and killed 12-year-old Katie Bender standing in a park about 430 yards (393 metres) across a lake from the hospital.[28] Witnesses said debris was launched more than 500 yards (>457 metres) from the blast site.[29]
- *Flyrock 197:* On June 7, 2022, blasting rock to make way for a residential subdivision in Hendersonville, Tennessee, launched

[24] Trivedi, R., Singh, T.N. and Raina, A.K., "Prediction of blast-induced flyrock in Indian limestone mines using neural networks," (2014) xxx Journal of Rock Mechanics and Geotechnical Engineering 1-8. <http://dx.doi.org/10.1016/j.jrmge.2014.07.003>.

[25] Albrecht, M., "Flyrock in orbit!," Linkedin, June 11, 2016. <https://www.linkedin.com/pulse/flyrock-orbit-mike-albrecht-p-e-/>, accessed 10 August 2023

[26] Hartwell, M., "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/>, accessed 10 August 2023.

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

[28] Inquest Findings, Katie Bender, 1999. <https://courts.act.gov.au/__data/assets/pdf_file/0017/1008080/Katie-Bender-redacted.pdf> accessed 11 August 2023.

[29] CNN, "Australian demolition kills young onlooker," *CNN World News*, July 13, 1997. <http://edition.cnn.com/WORLD/9707/13/australia.demo/>, accessed 10 August 2023.

flyrock debris that penetrated homes in a nearby Stonecrest subdivision.[30] 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.[31]

- *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.[32]
- *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.)[33]
- *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.[34]

---

30 WUSA9, "Hendersonville homes pelted with rock damage after blasting," WUSA9, YouTube, June 7, 2022. <https://www.youtube.com/watch?v=NFb9FzQ8Jkk>, accessed 10 August 2023.

31 Lee, T., "Construction Blast sends large rocks sailing in Stonecrest," *Hendersonville Standard*, June 7, 2022. <https://www.hendersonvillestandard.com/news/construction-blast-sends-large-rocks-sailing-in-stonecrest/article_aa882604-e6a5-11ec-b2dc-cb5e76379dc3.html> accessed 10 August 2023.

32 Colegrove, A., "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/> accessed 10 August 2023.

33 Vogt, D., "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/>, accessed 10 August 2023; US Army Corps of Engineers, '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.' <https://www.lrl.usace.army.mil/Media/News-Releases/Article/3271969/investigations-into-october-blasting-incident-complete/>, accessed 10 August 2023.

34 Herald Reports, "Tuesday's explosion came from county's rock quarry; no reported injuries," *Williamson Herald*, February 9, 2023.

- *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.[35]
- *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.[36]
- *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.[37]
- *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 Boulevard. Rock Breakers characterized "the blast…as no larger than other blast and that the damage was 'unforeseen.'"[38]
- *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

<https://www.williamsonherald.com/news/local_news/afternoon-explosion-at-rock-quarry-felt-throughout-franklin-beyond/article_009e1fa4-a806-11ed-9456-ff654fa9034c.html>, accessed 10 August 2023.

35 TOI, "18-year-old girl dies after getting hit by flyrock of mine blast in Jashpur district of Chhattisgarh," *The Times of India (TOI)*, 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>, accessed 10 August 2023.

36 Laird, L., "Quarry blast cuts power," *Northern Advocate*, October 16, 2006. <https://www.nzherald.co.nz/northern-advocate/news/quarry-blast-cuts-power/NIKAS2EQXP5N4KLS4JGYL54KD4/>, accessed 10 August 2023.

37 *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>, accessed 10 August 2023.

38 Byrne, R., "Blast pelts Sudbury neighbourhood with rocks," *Sudbury Star*, Aug 16, 2014. <https://www.thesudburystar.com/2014/08/16/blast-pelts-sudbury-neighbourhood-with-rocks>, accessed 10 August 2023.

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.[39]

- *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.[40]
- *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.[41]
- *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.[42]
- *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.[43]
- *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 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 (Karnataka). The quarry operators made attempts to destroy evidence. Six people, including the

[39] Roanoke Times, "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>, accessed 10 August 2023.

[40] Breslow, J., "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/>, accessed 11 August 2023.

[41] Lexington Herald Leader, "Blasts at Mercer quarry sends rock into windshield," *Lexington Herald Leader*, December 7, 2010. <https://www.kentucky.com/latest-news/article44067387.html>, accessed 11 August 2023.

[42] Ganesh, A., "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/>, accessed 11 August 2023.

[43] Fonseka, P., "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>, accessed 11 August 2023.

quarry owner, quarry operator and the suppliers of the explosives, were arrested.[44]

- *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 Freidman's studio, weighing about 150 pounds (68 kilograms), was one of three found on her property.[45]
- *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."[46]
- *Flyrock 213:* In April 2023, a blast at a quarry site in Virginia launched *flyrock debris* approximately 2,300 feet (701 metres) from the blast site and damaged a shed, and a rock landed next to a highway.[47]
- *Flyrock 214:* On March 23, 2000, a blast at a planned residential development site in Orange County, California, launched *flyrock debris* about 1,000 feet (305 metres) injuring six construction workers and damaging several vehicles, including a truck that had a window knocked out. Four workers were taken to local hospitals, one of whom suffered a broken leg. The others received cuts and scrapes from the flying debris. Two workers were treated and released at the scene.[48]
- *Flyrock 215:* On August 22, 2012, a blast at a construction site on Bonnyton Drive, Eaglesham, Scotland, launched *flyrock debris* that showered two nearby streets, causing extensive damage to cars and properties, including smashed windows and damaged roofs.

---

[44] DHNS, "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>, accessed 11 August 2023.

[45] McCarron, H., "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/>, accessed 11 August 2023.

[46] Federal Mine Safety and Health Review Commission, Civil Penalty Proceeding, June 1, 2007. <https://www.govinfo.gov/content/pkg/CFR-2004-title29-vol9/xml/CFR-2004-title29-vol9-subtitleB-chapXXVII.xml> accessed 11 August 2023.

[47] 'Safety Alert: *Flyrock*', *Virginia Energy*, May 9, 2023. <https://www.energy.virginia.gov/mineral-mining/documents/SAFETY/ALERTS/BlastingFlyrock/Safety%20Alert-Flyrock_20230509.pdf>, accessed 11 August 2023.

[48] Risling, G., "Six hurt in construction blast," *Daily Pilot*, March 24, 2000. <https://www.latimes.com/socal/daily-pilot/news/tn-dpt-xpm-2000-03-24-export61426-story.html>, accessed 11 August 2023.

Colin Robertson said rocks had damaged his car and came through the roof of his home. Vibrations from the blast cracked the foundation of Susan Fraser's home. Workmen from the construction site, who started clearing away the rocks in an effort to destroy evidence before police arrived, were told to stop five times by Susan Fraser.[49]

- *Flyrock 216:* On June 17, 2011, a blast at a construction site launched *flyrock debris* that damaged cars and windows in the parking lot of East Point Shopping Centre in Saint John, New Brunswick. One rock slammed into the side of the TD Canada Trust building and lodged into the outer wall. The blast was done by a certified blaster with 35 years of experience. "He had done the holes and everything according to the standards that are set." Ron Buchanan, a health and safety officer for Worksafe New Brunswick speculated that "[t]here was possibly a fault in the rock, which allowed the pressure of the blast to push the rocks out in this direction."[50]
- *Flyrock 217:* On September 1, 2020, a blast at a construction site launched *flyrock debris* about 1,000 feet (305 metres) that broke windows and damaged cars, one of which was occupied, at Lincoln Memorial University (LMU) in Harrogate, Tennessee. A 30-pound rock blew a hole through one of the buildings on campus. According to LMU Board of Trustees, Pete Debusk, the excavation blast hit a fault in the rock wall, and "when it has a fault in it, it just turns into a cannon."[51]
- *Flyrock 218:* On March 16, 2010, a blast at a construction site for a new 750,000-gallon water tank in Ketchikan, Alaska, launched onto an adjacent residential neighbourhood that struck a number of homes and vehicles, broke windows, damaged siding, and in at least one case penetrated a residence. An employee filming the blast was peppered with sand from the explosion. Southeast Earthmovers, Inc., the blasting company, argued that the flyrock occurred because of an undiscovered seam in the rock. However, the rock was generally known to be unpredictable.[52]
- *Flyrock 219:* On June 17, 2022, a blast at a quarry in Brazil launched *flyrock debris* that struck a 35-year old mining assistant while a

[49] Stewart, C., "Building site blast showers houses with rocks," *Glasgow Times*, August 23, 2012. <https://www.glasgowtimes.co.uk/news/13237133.building-site-blast-showers-houses-with-rocks/>, accessed 11 August 2023.

[50] CBC News, "Construction blast sends rock hurtling into cars," *CBC News*, June 20, 2011. <https://www.cbc.ca/news/canada/new-brunswick/construction-blast-sends-rock-hurtling-into-cars-1.1021105>, accessed 11 August 2023.

[51] Cole, S., "It sounded like a bomb | After explosion on campus, students say LMU should have given warning," *10News*, September 2, 2020. <https://www.wbir.com/article/news/education/after-explosion-on-campus-students-say-lmu-shouldve-given-warning/51-9081359c-1d8e-4e60-a66d-cf643376e838>, accessed 11 August 2023.

[52] *State of Alaska, et al. v. Southeast Earthmovers, Inc.*, Alaska Occupational Safety and Health Review Board, OAH No. 10-0326-OSH, 2013. <https://labor.alaska.gov/oshboard/do/10-2252-Southeast_Earthmovers.pdf>, accessed 11 August 2023.

> passenger in a work vehicle. The rock penetrated the roof of the vehicle and struck the mining assistant in the head. "The man suffered cranial trauma and died on scene."[53]

Previously, a total of approximately 195 flyrock incidents had been discovered and analyzed.[54] 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 24 flyrock incidents have been added to the "running list" of flyrock incidents bringing the total to 219. Of these additional 24 flyrock incidents, 10 people were injured, and 4 people were killed, indicating a kill rate of 16.7% (4 ÷ 24). Of the 219 flyrock incidents documented, 37 resulted in death from being struck by flyrock debris, reflecting a "kill" rate of 16.9% (37 ÷ 219), and 41 more people were injured in the same 37 flyrock incidents.

Globally, most flyrock incidents go unreported or unnoticed concealing the true extent of the potentially deadly consequences of flyrock caused by detonation of explosives to break rock in aggregate extraction operations.[55]

- *Flyrock debris* that does not leave the boundaries of a quarry site is not reported;
- *Flyrock debris* that does not injure anyone onsite or offsite (unless observed and reported by the public or media) is not reported;
- *Flyrock debris* that does not damage onsite quarry equipment or offsite personal or real property (unless observed and reported by the public or media) is not reported;
- *Flyrock debris* that is launched offsite but that goes unnoticed is not reported;
- *Flyrock debris* that is launched offsite into an uninhabited area or heavily treed area goes unnoticed and unreported;
- *Flyrock debris* that is launched offsite and goes unnoticed has the latent potential to damage lawn mowing and farming equipment, and injure the operator of the equipment.

5. QUANTITATIVE ANALYSIS OF FLYROCK DISTANCES

A non-theoretical *quantitative* study of actual distances that flyrock has been launched from a blast site was undertaken by Sevelka (2021)[56] in May 2021, and included in that analysis are 92 incidents of flyrock. Since

---

53 "Flyrock (part 01 of 03), *Linkedin*, August 12, 2022. <https://www.linkedin.com/pulse/flyrock-part-01-03-blasting-trainings>, accessed 11 August 2023.

54 Sevelka, T., "Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required," (2022) 5(4) Grassroots Journal of Natural Resources 66-98. <https://doi.org/10.33002/nr2581.6853.050405>.

55 Uthman, S., 'Into the 'cracks' Land (1): RCC Blasts Rocks for Lagos-Ibadan Road Construction, But Ogunmakin Suffers the Injury', (2021) Dataphyte, November 12.: <https://www.dataphyte.com/latest-reports/climate/into-the-cracks-land-1-rcc-blasts-rocks-for-lagos-ibadan-road-construction-but-ogunmakin-suffers-the-injury/>, accessed 01 August 2023.

56 Sevelka, T., "Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required," (2022) 5 (4) Grassroots Journal of Natural Resources 66-98. <https://doi.org/10.33002/nr2581.6853.050405>.

then, more incidents of flyrock have been documented, expanding the data set from 92 to 139 incidents of flyrock (August 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.

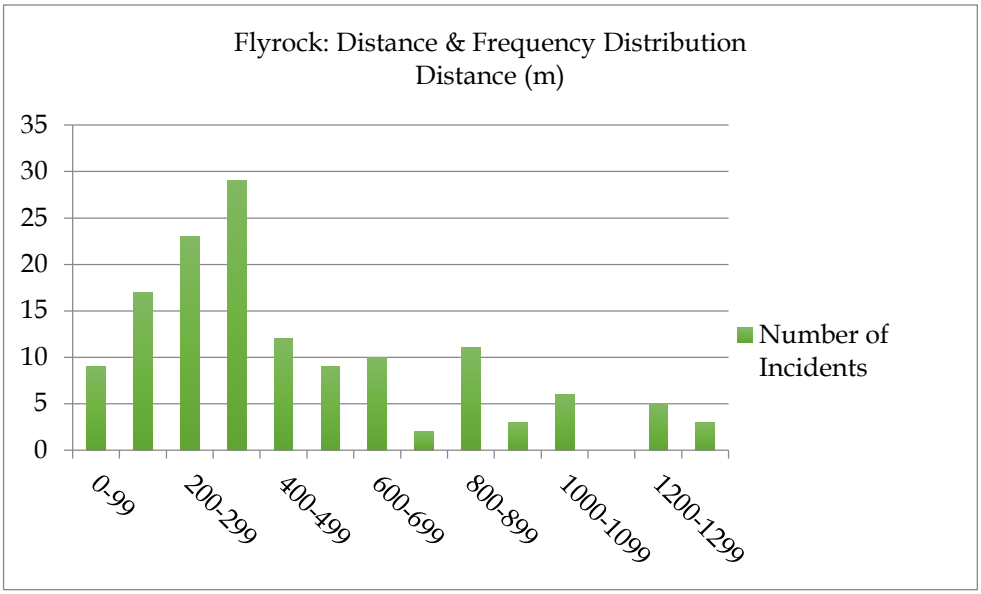

Figure 1: Analysis f Flyrock Travel Distances (May 2021; Updated August 2023)

The number of *flyrock* incidents within each interval, starting at between 0-99 metres, and the average distance travelled within each interval are summarized in table 1.

Table 1

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	29	12	9	10	2	11	3	6	0	5	3
Cumulative	-	26	49	78	90	99	109	111	122	125	131	131	136	139
Average (m)	59	148	240	327	440	512	616	701	803	916	1015	-	1225	2307
% of Total	6%	12%	17%	21%	9%	6%	7%	1%	8%	2%	4%	0%	4%	2%
Cumulative %	-	19%	35%	56%	65%	71%	78%	80%	88%	90%	94%	94%	98%	100%

The following analysis is based on the data summarized in Table 1:

- An analysis of 139 *flyrock* incidents, where the distance from the blast site is known, indicate that 94% (131) of the *flyrock* incidents occurred within 1,099 metres, and 98% (136) occurred within 1,299 metres.
- At 90%, of the 139 *flyrock* incidents, 125 *flyrock* incidents in ascending order reached a distance up to the 900 – 999 metre interval, and, at 94%, which accounts for the first 131 *flyrock*

incidents in ascending order, flyrock reached a distance up to the 1000 – 1099 metre interval.

- At 98%, of the 139 *flyrock* incidents, 136 *flyrock* incidents in ascending order reached a distance up to the 1200 – 1299 metre interval.
- On the basis of the this updated study of *flyrock* incidents (August 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.

Only with the benefit of hindsight after two flyrock incidents at a quarry operation in the Town of Paradise, Newfoundland, did it become apparent to mining regulators that a buffer of 300 metres to protect residents in nearby residential subdivisions against flyrock debris was inadequate, and which was subsequently increased to 1,000 metres in 1996.[57] Details of the increase in the width of the buffer requirement from 300 metres to 1,000 metres to protect the public from the potentially deadly consequences of flyrock are described in *City Sand and Gravel Ltd. et al v. Newfoundland (Minister of Municipal and Provincial Affairs)*, (2005):

> *"Stephen Jewczek…who was previously employed as the town planner at the [St. John's, Newfoundland] Metro Board….testified [that] any plan for Evergreen Village or Elizabeth Park [two residential subdivisions] should recognize that there is a [48-acre] quarry in the area. He also indicated planning should avoid conflicting uses [para. 24]."*[58] *City Sand and Gravel Ltd was not legally entitled to use or interfere with the use and enjoyment of adjoining or nearby third-party real property in the two residential subdivisions.*
>
> *By 1996…both Metro Board, and the Department of Mines, were of common intent in establishing a 300-metre buffer between a quarry operation and residential usages. The setting of a 300-metre buffer has not remained stagnant and changed significantly in 1996 [para. 64]….[I]n 1996 the Department of Municipal and Provincial Affairs, in its conditions for approval of quarry applications, required that…[a buffer zone of 1,000 metres be maintained] from a cottage or residence, if blasting quarry operations are carried out at the quarry… [para. 20]"*[59] [60]

---

57 On July 3, 1998, there was a third flyrock incident at the quarry, which launched flyrock debris that "caused damage to the roof of one resident of Jane Heights [an extension of Elizabeth Park] and the roof of another [para. 20]." *City Sand and Gravel Limited v. Newfoundland (Municipal and Provincial Affairs)*, 2007 NLCA 51 (CanLII), <https://canlii.ca/t/1sfnv>, accessed 15 July 2023.

58 *City Sand and Gravel Ltd. et al. v. Newfoundland (Minister of Municipal and Provincial Affairs)*, 2005 NLTD 67 (CanLII), <https://canlii.ca/t/fwvrv>, accessed 15 July 2023.

59 Ibid

60 St. John's, "Under the Development Regulations, a buffer not less than 1000 metres is required between a residential or apartment use and a mineral working area that involves blasting activity [p. 2]." <https://apps.stjohns.ca/escribe/archived/agenda/Regular%20Agenda%20-%20May%2013,%202019.pdf>, accessed 12 August 2023.

The Court of Appeal of Newfoundland and Labrador, (2007),[61] rejected the quarry owner's argument that *Metro Board* owed a *duty of care*[62] both to the residents of Jane Heights, an extension of Elizabeth Park subdivision, and to *City Sand and Gravel Ltd*. On this point, the appeal court commented as follows:

> *"A municipal authority reviewing a proposed residential development may owe a duty of care to future residents in respect of known hazards [e.g. an existing or proposed blasting quarry operation]. Though City Sand emphasized that point, it did not acknowledge directly that its blasting, which entailed the inherent risk of fly-rock, exposed it also to liability in tort to those same residents. As City Sand had no right to eject fly-rock outside the quarry site, the respondent argued that Metro Board owed no duty of care to City Sand. The trial judge agreed – Trial Decision para. 56. I see no fundamental flaw in that position. City Sand carried on a legitimate but inherently dangerous operation. It constituted a danger to persons and property outside the quarry site. Prior to the development of Jane Heights, neither the owner of the land comprising that development, nor Metro Board, found it necessary to take legal action in respect of fly-rock landing outside the quarry site. City Sand could not however compel Metro Board to restrict development of adjacent land so that a public danger would not be created" [p. 54].*

5.1 Trespass – Flyrock and Vibration

The Factum of the Interveners[63] in the *Castonguay* case before the Supreme Court of Canada, (2013), which involved a *flyrock* incident, describes *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.*, (1963),[64] 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*

---

61 Ibid, supra 58

62 *Duty of care* is defined as "a legal obligation imposed on an individual [or legal entity] to take reasonable care to avoid causing harm to another who might reasonably be affected and who ought to be in the individual's [or legal entity's] contemplation, p. 277, C. A. MacLean, L. M. Olivo and J. Fitzgerald, Contract and Tort Law, Second Edition, ©2018, Emond, Toronto, Canada.

63 <https://cela.ca/wp-content/uploads/2019/07/Castonguay-SCC-Factum.pdf>, accessed 12 August 2023.

64 *Enos Coal Mining Company v. Schuchart et al.*, 243 Ind. 692 (1963) 188 N.E.2d 406, <https://casetext.com/case/enos-coal-mining-co-v-schuchart-et->, accessed 11 August 2023.

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."*

6. NUISANCE AND THE RULE OF RYLANDS (STRICT LIABILITY)

According to Grant (2017),[65] 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 [and use] 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.*[66]
> *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*

[65] 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>, accessed 12 August 2023.

[66] *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>, accessed 12 August 2023.

> *facie answerable for all the damage which is the natural consequence of its escape."*

The three criteria 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].*[67]

7. CONFLICTING LAND USES, LONG-TERM LAND USE PLANNING AND PRECAUTIONARY PRINCIPLE

Aggregate extraction operations can remain operational indefinitely in jurisdictions such as Ontario, Canada, where a license or permit issued to extract aggregate has no expiry date, which means that the adverse effects suffered by the surrounding communities are effectively permanent. Accordingly, municipal land use planning (e.g. zoning, official plan, master plan, etc.) should be undertaken in a manner that supports anticipated population growth long-term, while simultaneously restricting aggregate extraction operations to locations far enough removed from sensitive land uses, existing and planned, that do not interfere with the use and enjoyment of private third-party property or the health, safety and welfare of existing and future generations. This proactive and forward-looking approach to land use planning is consistent with the Precautionary Principle, which in essence holds that it is "better to be safe than sorry."

In *EQT Production v. Borough Jefferson Hills*, (2019),[68] three objectors provided relevant, probative and credible testimony as to the adverse effects on the environment and the impact on health and quality of life (use and enjoyment of property), and attendant loss in property value, as a consequence of residing in proximity to the "Trax Farm site," a similar natural gas extraction operation in Union Township, Pennsylvania. EQT purchased easements and rights-of-way, characterized as "gag agreements" by one objector, over nearby properties for "noise, dust, light, smoke, odours, fumes, soot or other pollution [and] vibrations" and other adverse impacts which may emanate from EQT's Trax site operations. EQT was not entitled to the free use of adjoining land as a "dumping ground" for the adverse impacts that EQT could not prevent from leaving the boundary limits of the Trax site. Precautionary and proactive planning measures (e.g. permanent onsite setbacks coupled with offsite separation distances) could have prevented the land use conflicts, preserved property values, and protected the environment, and the health and safety of existing and future residents of the community, deleterious impacts that

---

[67] MacLean, C. A., Olivo, L. M. and Fitzgerald, J., *Contract and Tort Law*, Second Edition (2018, Emond, Toronto, Canada).

[68] *EQT Production v. Borough Jefferson Hills***,** 208 A.3d 1010 (2019). <https://casetext.com/case/eqt-prod-co-v-borough-of-jefferson-hills->, accessed 12 August 2023.

cannot be overcome by any amount of money paid to purchase easements and rights-of-way over properties near the Trax site operations.

> *"…Bob Domman related that because "the Trax site was probably the closest one to where I lived, we followed that pretty closely," and he testified that EQT had offered what he characterized as "gag agreements" to individuals who lived next to the site, and he provided Council with copies thereof which were entered into the evidentiary record. N.T. Jefferson Hills Council Public Hearing ("Hearing"), 11/10/15, at 138, 143. Because these individuals had apparently complained that EQT's extraction activities at the Trax Farm site constituted a nuisance which interfered with the use and enjoyment of their property, the agreements provided that, in exchange for a $50,000 cash payment, the residents would grant EQT easements and rights-of-way over their properties for "noise, dust, light, smoke, odors, fumes, soot or other pollution, [and] vibrations ... [and other] adverse impacts or other conditions or nuisances which may emanate or be caused by [EQT's] operations." Id. at 139-40. These easements were for varying lengths of time, ranging from one year to perpetuity. Id. at 140."*

As reported in *The Magazine of Mining Health and Safety (MESA)*, (1978),[69] "being too close" to the blast was the most frequently cited reason for property damage, injury and death from flyrock:

> "*Of 34 accidents that occurred during scheduled blasting, 28 involved death, injury or property damage as a result of flyrock striking persons, equipment, buildings or other property the MESA reports showed. Where flyrock was the agent, "being to close" to the blast was the reason most frequently listed in the accident reports on death and injuries of miners. In one case…a 37-year-old miner with 12 years of mining experience was 1,600 feet [488 metres] from the blast when he was struck and killed by a flying rock fragment attributed to undetected fissures in the rock being blasted. Flyrock which travelled 1,200 feet [366 metres] through the air left another miner an invalid for life. In still other instances, flyrock broke the leg of a miner who was 2,500 feet [762 metres] from the explosion and damaged nine houses located from 1,650 [feet] [503 metres] to 2,000 feet [610 metres] from the center of the blast [p. 5]."*

In applying the *precautionary principle*, the Federal Republic of Nigeria National Environmental (Quarrying and Blasting Operations) Regulations, 2013, preclude blasting quarry operations from locating within certain distances from sensitive land uses to prevent potential adverse effects and any form of human discomfort:[70]

> *20. A person shall not locate a quarry or engage in blasting within three kilometers (3km) of an existing residential, commercial or industrial area.*

---

[69] The Magazine of Mining Health and Safety (MESA), December-January 1978. <https://books.google.ca/books?printsec=frontcover&id=SwNl7rxA5ugC#v=onepage&q&f=false>, accessed 13 August 2023.

[70] National Environmental (Quarrying and Blasting Operations), 2013. <https://faolex.fao.org/docs/pdf/NIG208283.pdf>, accessed 12 August 2023.

> *22. – (1) A person shall not blast in such a way that the impact of such blast will cause any form of discomfort or nuisance to the public and residents within 1,000 meters from the epicenter of the site or users of the users of the roads thereof.*
> *22.(2) Subject to the provisions of these Regulations, the act of blasting shall be complete, whether or not the alleged act is preceded or accompanied with vibration, noise, air over pressure, fly rock, dust, fumes, or that the impact is felt within 1,000 meters from the site or epicenter of the blasting.*

8. BLASTING OPERATIONS ARE DANGEROUS AND MUST PAY THEIR OWN WAY

While it is recognized that aggregate extraction operations are "necessary" for construction of structures, buildings and roads in support of economic activity, it is not "reasonable" for a private company such as a blasting aggregate operation to enhance profits by interfering (directly or indirectly) with the use and enjoyment of land owned by neighbouring property owners who do not share in the profits of a private for-profit enterprise. In this respect, the Supreme Court of Indiana in *Enos Coal Mining Co. v. Schuchart et al.*, (1963), made the following observations:

> *"It is also urged that in business and industry certain operations are "necessary" for the encouragement of industrial development and that even though such business activities cause some injury to neighbouring properties, a "reasonable use" is permissible. From our viewpoint, this is to say that "a little damage" is "reasonable" and legal, but too much damage is "unreasonable" and wrong. What is or is not "reasonable" is an uncertain yardstick. Although it is a standard of conduct in some cases because of the lack of a better one, it is to be avoided, so far as possible, because of its vagueness and lack of certainty.*
> *"The individual citizen may be deprived of his home or other property by the proper exercise of the power of eminent domain; but it ought not to be said that it can be lawfully destroyed without compensation in the interest of a mere business enterprise, simply because such enterprise is of great magnitude and general public interest." Watson v. Mississippi R.P. Co. (1916), 174 Iowa 23, 34, 156 N.W. 188*[71].

9. CONCLUSION

As this article demonstrates, flyrock is an ever-present danger whenever blasting to break rock is conducted, and the different formulas used to calculate the "throw" distance of flyrock are unscientific and unreliable. 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, as well as the other impacts associated with blasting quarry operations. Flyrock is an inevitable by-product of blasting rock, and as

[71] <https://case-law.vlex.com/vid/watson-v-miss-river-889538033>, accessed 12 August 2023.

flyrock can never be brought down to "zero" proactive and preventive land use provisions are warranted. Mandatory minimum setbacks (extraction limit) imposed on the lands slated for aggregate extraction coupled with a mandatory separation distance between the boundaries of a proposed quarry site and existing (and potential future) sensitive land uses are the only effective means of avoiding or mitigating damage to personal and real property, and the potentially deadly consequences of flyrock to human and non-human life. 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 139 flyrock incidents from a blast site presented in this paper provide municipalities and its Land Use Planners with an evidence-based rationale for avoiding land use conflicts, preserving property values, and mitigating the potentially deadly consequences of flyrock (and the other impacts associated with blasting quarry operations) by the enactment of permanent minimum onsite setbacks (extraction limits) combined with offsite permanent minimum separation distances from existing and future sensitive land uses.

REFERENCES

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>, accessed 12 August 2023

Albrecht, M., "Flyrock in orbit!," Linkedin, June 11, 2016. <https://www.linkedin.com/pulse/flyrock-orbit-mike-albrecht-p-e-/>, accessed 10 August 2023

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>, accessed 10 August 2023

Balakrishnan, V. and Rai, P., "An Overview of Flyrock and its Prediction in Surface Mine Blasting using Soft Computing Techniques," (2021) 2 (2) Recept Tayyip Erdogan University Journal of Science and Engineering 105-119. <https://dergipark.org.tr/tr/download/article-file/1941187>, accessed 10 August 2023

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

Breslow, J., "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/>, accessed 11 August 2023

Byrne, R., "Blast pelts Sudbury neighbourhood with rocks," *Sudbury Star*, Aug 16, 2014. <https://www.thesudburystar.com/2014/08/16/blast-pelts-sudbury-neighbourhood-with-rocks>, accessed 10 August 2023

CBC News, "Construction blast sends rock hurtling into cars," *CBC News*, June 20, 2011. <https://www.cbc.ca/news/canada/new-brunswick/construction-blast-sends-rock-hurtling-into-cars-1.1021105>, accessed 11 August 2023

CNN, "Australian demolition kills young onlooker," *CNN World News*, July 13, 1997. <http://edition.cnn.com/WORLD/9707/13/australia.demo/>, accessed 10 August 2023

Cole, S., "It sounded like a bomb | After explosion on campus, students say LMU should have given warning," *10News*, September 2, 2020. <https://www.wbir.com/article/news/education/after-explosion-on-campus-students-say-lmu-shouldve-given-warning/51-9081359c-1d8e-4e60-a66d-cf643376e838>, accessed 11 August 2023

Colegrove, A., "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/> accessed 10 August 2023

DHNS, "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>, accessed 11 August 2023

Federal Mine Safety and Health Review Commission, Civil Penalty Proceeding, June 1, 2007. <https://www.govinfo.gov/content/pkg/CFR-2004-title29-vol9/xml/CFR-2004-title29-vol9-subtitleB-chapXXVII.xml> accessed 11 August 2023

Fonseka, P., "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>, accessed 11 August 2023

Ganesh, A., "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/>, accessed 11 August 2023

Hartwell, M., "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/>, accessed 10 August 2023

Herald Reports, "Tuesday's explosion came from county's rock quarry; no reported injuries," *Williamson Herald*, February 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>, accessed 10 August 2023

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" (2021) 13 (1) Journal of Rock Mechanics and Geotechnical Engineering 1438-1451. <https://doi.org/10.1016/j.jrmge.2021.07.007>

Laird, L., "Quarry blast cuts power," *Northern Advocate*, October 16, 2006. <https://www.nzherald.co.nz/northern-advocate/news/quarry-blast-cuts-power/NIKAS2EQXP5N4KLS4JGYL54KD4/>, accessed 10 August 2023

Lee, T., "Construction Blast sends large rocks sailing in Stonecrest," *Hendersonville Standard*, June 7, 2022. <https://www.hendersonvillestandard.com/news/construction-blast-sends-large-rocks-sailing-in-stonecrest/article_aa882604-e6a5-11ec-b2dc-cb5e76379dc3.html> accessed 10 August 2023

Lexington Herald Leader, "Blasts at Mercer quarry sends rock into windshield," *Lexington Herald Leader*, December 7, 2010. <https://www.kentucky.com/latest-news/article44067387.html>, accessed 11 August 2023

Lwin, M.M. & Aung, Z.M., "Prediction and Controlling of Flyrock due to Blasting for Kyaukpahto Gold Mine," (2019) 5 (10) International Journal of Advances in Scientific Research and Engineering 338-346. <https://doi.org/10.31695/IJASRE.2019.33574>

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

McCarron, H., "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/>, accessed 11 August 2023

Rathore, S.S. and Jain, E.S.C., "Studies on flyrock at soapstone quarry for safe working," (2007) Vienna Conference Proceedings, European Federation of Explosives Engineers, <https://www.efee.eu/wp-content/uploads/2016/04/7-Health-Safety-and-Environment.pdf>, accessed 10 August 2023

Risling, G., "Six hurt in construction blast," *Daily Pilot*, March 24, 2000. <https://www.latimes.com/socal/daily-pilot/news/tn-dpt-xpm-2000-03-24-export61426-story.html>, accessed 11 August 2023

Roanoke Times, "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>, accessed 10 August 2023

Rock Blasting, "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>

Sauvage, A.C., "Flyrock: French Experience," (2017) 61 SAFEX Newsletter, <https://ap3e.pt/wp-content/uploads/2021/03/2017-2-Newsletter-61.pdf>, accessed 10 August 2023

Sevelka, T., 'Preventing the Potentially Deadly Consequences of Flyrock: Mandatory Minimum Setbacks and Separation Distances Required', (2022) 5(4) Grassroots Journal of Natural Resources 66-98. <https://doi.org/10.33002/nr2581.6853.050405>

Shi, J., An, H. and Wu, C., 'Regression and Fitting Analysis of Flyrock Prediction Formulae for Loosening Blasting' (2013) 405-408 Applied Mechanics and Materials 2346-2350

St. John's, "Under the Development Regulations, a buffer not less than 1000 metres is required between a residential or apartment use and a mineral working area that involves blasting activity [p. 2]." <https://apps.stjohns.ca/escribe/archived/agenda/Regular%20Agenda%20-%20May%2013,%202019.pdf>, accessed 12 August 2023

Stewart, C., "Building site blast showers houses with rocks," *Glasgow Times*, August 23, 2012. <https://www.glasgowtimes.co.uk/news/13237133.building-site-blast-showers-houses-with-rocks/>, accessed 11 August 2023

Szendrei, T. and Tose, S., 'Flyrock in surface mining – Limitations of current predictive models and a better alternative through modelling the aerodynamics of flyrock trajectory' (2022) 122 (12) J. S. Afr. Inst. Min. Metall., <https://dx.doi.org/10.17159/2411-9717/1873/2022>

TOI, "18-year-old girl dies after getting hit by flyrock of mine blast in Jashpur district of Chhattisgarh," *The Times of India (TOI)*, 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>, accessed 10 August 2023

Trivedi, R., Singh, T.N. and Raina, A.K., "Prediction of blast-induced flyrock in Indian limestone mines using neural networks," (2014) xxx Journal of Rock Mechanics and Geotechnical Engineering 1-8. <http://dx.doi.org/10.1016/j.jrmge.2014.07.003>

Uthman, S., 'Into the 'cracks' Land (1): RCC Blasts Rocks for Lagos-Ibadan Road Construction, But Ogunmakin Suffers the Injury', (2021) Dataphyte, November 12.: <https://www.dataphyte.com/latest-reports/climate/into-the-cracks-land-1-rcc-blasts-rocks-for-lagos-ibadan-road-construction-but-ogunmakin-suffers-the-injury/>, accessed 01 August 2023

van der Walt, J. and Spiteri, W., "A conceptual technique to mathematically quantify the trajectory of flyrock" (2023) 123 (4) Journal of Southern African Institute of Mining and Metallurgy165-174. <https://issuu.com/saimm/docs/saimm-202304-apr/s/25372330>, accessed 10 August 2023

van der Walt, J., 'A Critical Analysis of Recent Research into the Prediction of Flyrock and Related Issues Resulting from Surface Blasting Activities' (2020) 120 (12) J. S. Afr. Inst. Min. Metall. <http://dx.doi.org/10.17159/2411-9717/1103/2020>.

Vogt, D., "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/>, accessed 10 August 2023

WUSA9, "Hendersonville homes pelted with rock damage after blasting," WUSA9, YouTube, June 7, 2022. <https://www.youtube.com/watch?v=NFb9FzQ8Jkk>, accessed 10 August 2023

AUTHOR'S DECLARATION AND ESSENTIAL ETHICAL COMPLIANCES

Authors' Contributions (in accordance with ICMJE criteria for authorship)
This article is 100% contributed by the sole author. S/he conceived and designed the research or analysis, collected the data, contributed to data analysis & interpretation, wrote the article, performed critical revision of the article/paper, edited the article, and supervised and administered the field work.

Funding
No funding was available for the research conducted for and writing of this paper. Therefore, acknowledging any support agency is not applicable in case of this research or the written work. However, informal support of institutional supervisors, colleagues and respondents is duly acknowledged.

Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals not even indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved any Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge, if any, are only indirectly covered, if any, through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment or field studies. The contexts of plants are only indirectly covered through literature review. Yet, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

(Optional) Research Involving Local Community Participants (Non-Indigenous)
The author(s) solemnly declare(s) that this research has not directly involved any local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people are only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

Attribution and Representation
All opinions and mistakes are the author(s)' own and cannot be attributed to the institutions they represent. The publisher is also not responsible either for such opinions and mistakes in the text or graphs or images.

Rights and Permissions

Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

***

To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Ethical Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/jelp03.02.01.