

THE ICE CLIMBING AVALANCHE ATLAS

Grant Statham^{1,2*} and Sarah Hueniken³

¹ Parks Canada Agency, Banff, AB, Canada

² Simon Fraser University, Burnaby, BC, Canada

³ Avalanche Canada, Revelstoke, BC, Canada

ABSTRACT: Waterfall ice climbing is popular in the Canadian Rockies, where hundreds of high-quality routes form reliably every year from November to April. Banff, Yoho, and Kootenay (BYK) national parks are home to some of the best ice climbing in the world. Waterfall ice climbs usually form in drainages and these gullies are often avalanche paths that pose a significant risk to climbers. As far back as 1980, local ice climbing guidebooks (Sole, 1980) have described avalanches as a significant hazard, although with little detail. Avalanche fatalities in these parks bear this out: over the past 25 years in BYK, 33% of all avalanche fatalities were climbers, while 43% were skiers (n: 30). Considering that the number of skiers in these parks far exceeds the number of climbers, climbers likely have a substantially higher risk of dying from avalanches than skiers. Furthermore, the nature of the climbing accidents is different, because 70% of those climbers killed by avalanches were hit by natural avalanches that started overhead.

In winter 2021/22, Avalanche Canada, Parks Canada and Kananaskis Country joined forces to develop an ice climbing avalanche atlas. The concept mirrors a traditional avalanche atlas, but for popular waterfall ice climbs located in avalanche terrain. Online surveys were used to crowdsource information on avalanche frequency and historic avalanche information, which was then combined with avalanche path mapping and terrain data. The result to date, is detailed avalanche path information for 14 popular waterfall ice climbs, each accompanied by an Avalanche Terrain Exposure Scale (ATES) rating. The atlas is available on Avalanche Canada's website alongside public avalanche forecasts, conditions reports and remote weather station data to provide a comprehensive stream of avalanche information for ice climbers.

KEYWORDS: Ice climbing, avalanche atlas, risk, terrain

1. INTRODUCTION

The Canadian Rockies is one of the best waterfall ice climbing locations in the world. Hundreds of ice climbs form every winter starting in early November through to late April. Many of these routes are easily accessed from trailheads in the national and provincial parks. With towns to base from in Canmore, Banff, Lake Louise, Field, Golden and Jasper, ice climbing here is becoming ever more popular, and climbs are getting busier and busier.

But ice climbing is dangerous, this is a well-known fact (Figure 1). Legions has been written on the risk and suffering of ice climbers, causing logical people to ask, "why do you do it?"

In the Canadian Rockies, avalanches are the single greatest hazard to waterfall ice climbers (Josephson, 1994). Discussion and warnings of avalanche risk date back to the earliest waterfall ice climbing guidebooks (Sole, 1980).

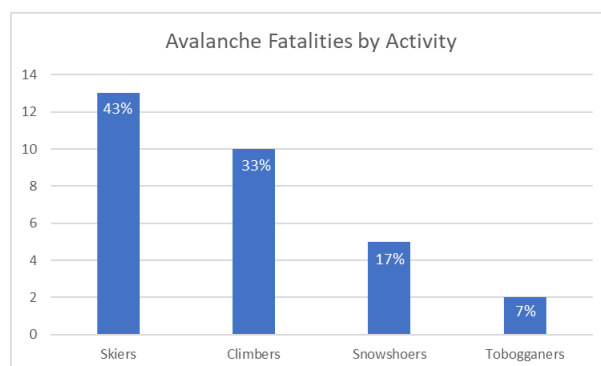


Figure 1: Avalanche fatalities by activity, from 25 years of avalanche fatalities in BYK (n: 30).

* Corresponding author address:

Grant Statham, Parks Canada Agency
Box 900, Banff, Alberta, Canada, T1L 1K2
T: +01 403 760 0510, E: grant.statham@pc.gc.ca

The Canadian Rockies are big mountains. They're steep, rocky and impressive looking peaks with up to 2000 m (6500 ft) of relief from valley to summit. Ice climbs form in gullies down low in the forest

and up high on the peaks. These climbs range from easy, beginner crags in the valley bottom to some of the hardest climbing in the world up on huge, sweeping cliffs. Most climbs form in gullies where the water flows and ice freezes, but these same gullies are also often avalanche paths. It's not uncommon to spend a full day climbing inside an avalanche path with a large starting zone overhead.

This is reflected in the fact that in BYK, 70% of climbers killed by avalanches were hit by one that started naturally from above. This stands in stark contrast to skiers, for whom 92% triggered the avalanche themselves (Figure 2).

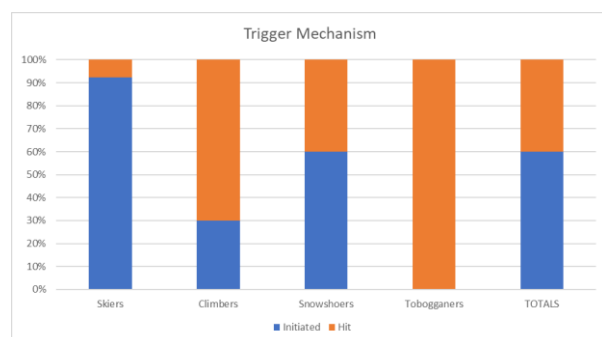


Figure 2: Avalanche fatalities by trigger mechanism, from 25 years of avalanche fatalities in BYK (n: 30).

Accordingly, waterfall ice climbers are in, under or around avalanche hazard a lot; it's a serious occupational hazard if you're an ice climber. Despite this, descriptive information on avalanche hazard for specific climbs has historically been hard to find. Early guidebook descriptions focused on the attributes of the climb itself, adding avalanche risk as an afterthought but sometimes saying nothing (Josephson, 1994). Certainly few details were provided to help manage the risk. Similarly, climbers have been historically slow to take up the mantle of avalanche safety and have only recently started using avalanche safety gear routinely.

The ice climbing avalanche atlas seeks to fill an important void in the sport of waterfall ice climbing, and that is to provide detailed avalanche terrain and risk information about the climbs. The goal is to develop a legacy of avalanche information for the most popular climbs and to make this information available through Avalanche Canada,

alongside public avalanche forecasts, conditions reports and real-time weather station data.

2. AVALANCHE ATLASES

An avalanche atlas is a map or collection of maps that portrays avalanche hazard. They show where avalanches have been known to occur and provide technical information like distance to major landmarks, starting and runout zone elevations, vertical relief and avalanche frequency. They are powerful tools for avalanche forecasters and are widely used in the avalanche forecasting industry (Figures 3 and 4). Every ski resort, highway, railway and utility corridor that manages avalanche risk will have an avalanche atlas; they're industry standard.

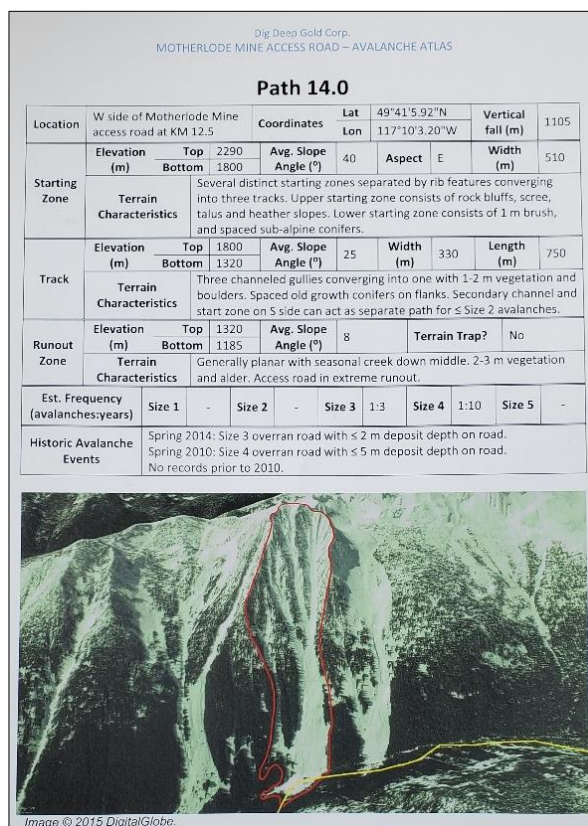


Figure 3: Typical roadway avalanche atlas (CAA, 2016).

An avalanche atlas can be built for any avalanche path that can be studied and mapped, and with today's geospatial tools, measuring terrain attributes like vertical relief, distance and surface area is easy. Drones can gather effective photos and online survey tools exist to query the population on their experiences with avalanches.

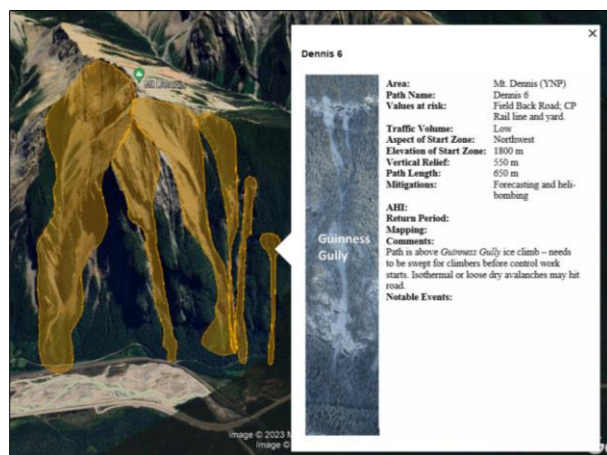


Figure 4: Avalanche atlas information for Dennis 6 (aka: Guinness Gully) in Yoho National Park.

But the only way to really learn these climbs and their terrain is to climb them, repeatedly. This develops a detailed understanding of the terrain on the climb, influencing decisions about when and how to climb the route. Without this, truly understanding the avalanche risk on a particular climb can be difficult, as simply looking up is not enough. Foreshortening effects and a general inability to see the upper part of the climb and overhead hazard means climbers can sometimes be unaware of the terrain they are in, or under. The ice climbing avalanche atlas seeks to correct that information void.

3. COMMUNITY SURVEY

There is little recorded history of avalanche activity on ice climbs other than recorded incidents (e.g., Jamieson et al., 2007; Holeczi and Statham, 2016), anecdotal stories and local knowledge. Certainly, there is much to be learned and shared about the patterns of avalanche activity unique to each climb, and this was the objective of the community surveys.

Using free, online survey tools, respondents were asked to recall the number of times they climbed a route, at what time of the season, in what sort of conditions, whether or not they had witnessed an avalanche, and how often they had observed avalanche debris in the gullies. Survey answers provided information on when people chose to climb specific routes, why and what they observed. An important objective was to get a sense of avalanche frequency: does it slide more than once per year, annually, or every ten years? The survey

concluded with room to add further information and it was here that many important stories and lessons of near-misses and incidents were told.

Survey participants were solicited through Facebook ice climbing groups and professional guiding networks. An average of 47 people completed each survey, ranging from 14 to 109 respondents per climb. Professional guides (ACMG/AMGA) made significant contributions to the surveys and participants were asked how often they had climbed the route, as their observations were weighted differently if they were there ten times versus only once.

The surveys rely on the ability of respondents to recall their own personal history with each climb. The results are an anecdotal snapshot of perceived avalanche risk on each climb. Combined with conditions reporting on Avalanche Canada's Mountain Information Network (MIN), the atlas is a starting point for gathering factual avalanche information about each climb. It is a means to capture historical data and an attempt to learn trends, frequencies and stories of avalanches and near misses.

4. AVALANCHE MAPPING

Avalanche mapping is the process of analysing avalanche terrain information and presenting the results on a map or photograph. Terrain can be analysed more objectively than snow, given that its geographic parameters are measurable and don't change, so avalanche maps are reliable planning tools. Maps create a spatial reference for risk assessment and are an excellent route planning resource for ice climbers as they present the entire route in perspective with the avalanche terrain highlighted.

4.1 *Oblique photography*

The ice climbing atlas uses oblique photographs to show the route in perspective, removing the effects of foreshortening that result from looking up at vertical relief from the bottom (Figures 5 and 6). Oblique photographs are low-level photographs taken from an opposite side of the valley or from an aircraft and provide an excellent perspective of avalanche terrain (CAA, 2016). This has the effect of revealing the true size of the avalanche terrain, which is particularly important when assessing overhead hazard that is hard to see from below.

Obliques for the atlas were taken from helicopters, drones and by hiking to nearby viewpoints to get the correct perspective. Obtaining high quality images that show the approach, climb, and overhead hazard is essential.

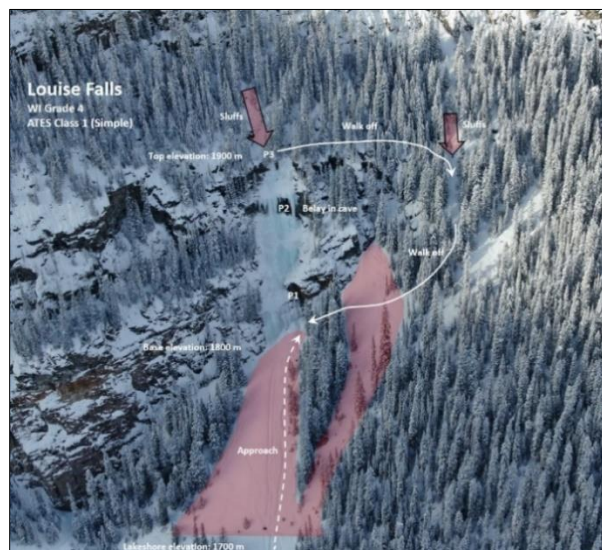


Figure 5: Louise Falls avalanche mapping.

4.2 Drawing tools

Once the images have been acquired, the next step is to import them into a digital drawing tool and begin highlighting the avalanche terrain, normally with a polygon drawn around the boundaries of the starting zone, track and runout zone (Figure 6). The Canadian Avalanche Association provides standards for avalanche mapping (CAA, 2016).

It is important to highlight all the avalanche terrain that affects the climb, and to ensure the ice pitches on the route remain visible and obvious in the photo. Usually this requires several different images taken at different angles and elevations to ensure all the terrain and ice pitches are captured. Polygons require testing different transparencies to ensure the climb itself remains visible through the colour.

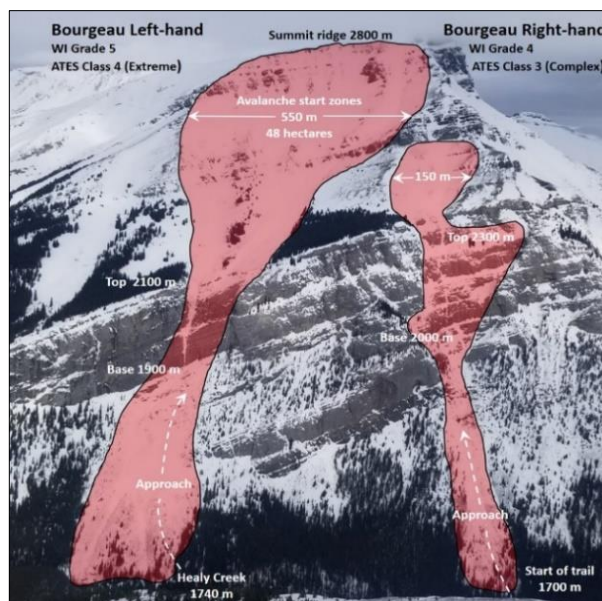


Figure 6: Mt. Bourgeau avalanche mapping.

4.3 Geographic data and route beta

Once polygons have been drawn around the avalanche terrain, then terrain measurements need to be taken and transposed onto the image using arrows, lines, and labels. Common measurements include elevation, vertical relief, slope angle, slope length, width and surface area. Starting zone dimensions are a crucial part of the information, as they impart the real size of the terrain. All these measurements can be easily obtained using free Geographic Information System (GIS) platforms such as Google Earth. In addition to measurements, prominent landmarks such as summits, rivers, trails and parking lots should also be identified, along with important features (aka: beta) of the climbing route itself such as the approach, the pitches and the descent (Figures 5 and 6).

5. AVALANCHE TERRAIN RATING

Every route is given an avalanche terrain rating using the Avalanche Terrain Exposure Scale (ATES; Statham and Campbell, 2023). The ATES uses two models: a *Technical Model* for assessing avalanche terrain and a corresponding *Communication Model* (Table 1) for outreach to climbers. ATES ratings should be a collaborative, peer reviewed effort among a group of climbers who have intimate familiarity with the route.

Table 1: Avalanche Terrain Exposure Scale (ATES) for waterfall ice climbing.

Terrain rating	Class	Description for waterfall ice climbing
Non-avalanche	0	Routes with no exposure to avalanches except small sluffs and spindrift.
Simple	1	Routes with brief exposure to very low frequency avalanches starting from above or crossing occasional short slopes.
Challenging	2	Routes with long exposure to low frequency avalanches or brief exposure to high frequency avalanches starting from above or crossing a few short slopes. Options to reduce exposure.
Complex	3	Routes with long exposure to high frequency avalanches starting from above or crossing steep slopes with terrain traps below. Minimal options to reduce exposure.
Extreme	4	Routes with long and sustained exposure to very high frequency avalanches starting from above and crossing multiple steep slopes with terrain traps below. No options to reduce exposure.

6. THE ICE CLIMBING AVALANCHE ATLAS

After the community survey closes, the information is analysed, organized and collated into a format to accompany the mapping for each route. Each atlas presents an introduction to the climb, followed by survey results that describe the popularity, estimated avalanche frequency, time of year and day, start zone, runout zone, contributing factors and reported avalanches and incidents. This information is then combined with avalanche maps and posted to:

<https://www.avalanche.ca/resources/ice-climbing/atlas>

Some examples are shown below:

Cascade Waterfall is one of the most popular climbs in the area at a moderate grade of WI3, but it has significant overhead hazard that runs over the climb almost annually. Figure 7 describes Cascade Waterfall, its popularity, highlights the overhead hazard, shows elevations and starting zone dimensions, and provides directional information for the climb and descent. 64 people completed the survey for Cascade Waterfall.

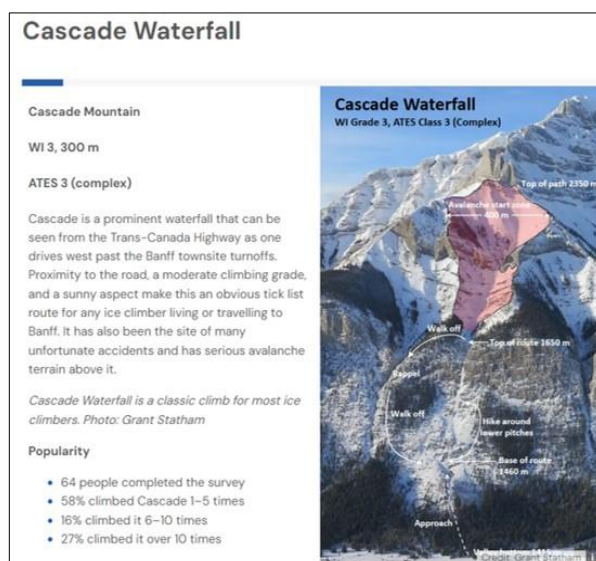


Figure 7: Cascade Waterfall description, mapping and popularity of the survey.

Bourgeau Right-Hand is a popular climb rated ATES class 4 due to high frequency avalanches and exposure to starting zones both while climbing on the route, and from overhead. Figure 8 illustrates the overhead hazard and shows an alternative walk-off descent. While rappelling back down on fixed anchors has become common practice on popular climbs, many routes have walk-off options which provide an important alternative.

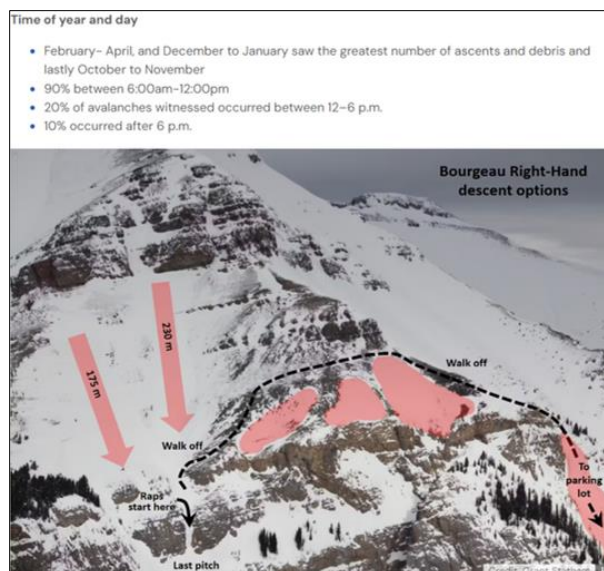


Figure 8: Overhead starting zone and walk-off option for Bourgeau Right-Hand.

Polar Circus is a huge, complex route with 1560 m (5100 ft) of vertical relief from the bottom of the avalanche path to the top. This atlas uses six different maps to present all aspects of the terrain. 46 people contributed to the survey, including many professional guides and experienced climbers with 15% of the survey group having climbed the route more than 10 times (Figure 9).

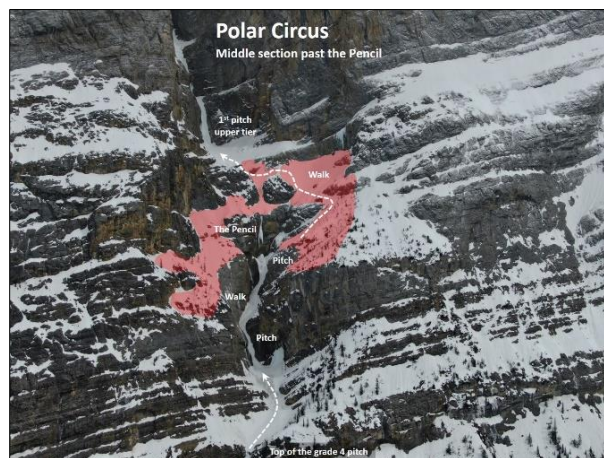


Figure 9: Middle section of Polar Circus passing the Pencil, the site of many incidents.

The Professor Falls is a popular WI4 ice climb located near Banff that is climbed hundreds of times every winter by locals, guides and visiting climbers (Figure 10). 109 people took the Professors survey and 28% of those people reported climbing Professors more than 10 times.

The survey revealed many new stories of close calls with avalanches and observations of avalanche debris low down on the climb, resulting in a change to the ATES rating. This was not a surprise considering the Professors avalanche path covers 1400 m (4600 ft) of vertical relief on the North Face of Mt. Rundle.

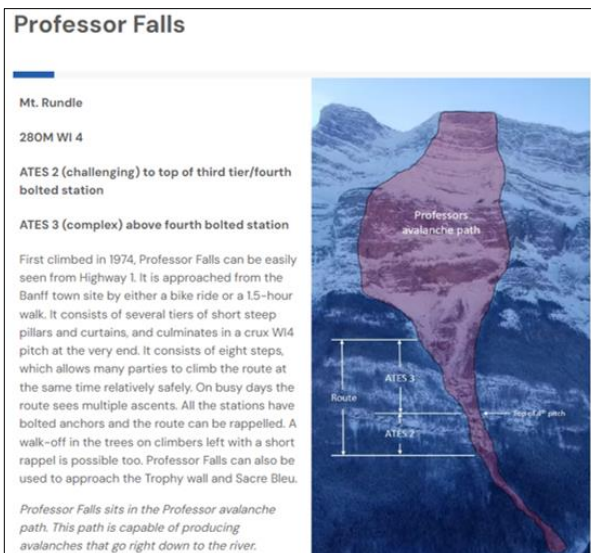


Figure 10: The Professor Falls with its description and mapping showing the avalanche path and ATES ratings divided by elevation.

7. CONCLUSION

Avalanche hazard assessment and forecasting for waterfall ice climbing is a challenging exercise. Understanding the terrain that lies above a climb, as well as the complexities and seriousness of the terrain on the route itself is essential. Knowledge of this terrain then needs to be paired with a solid understanding of the avalanche conditions leading up to the day, and real-time monitoring of snowpack and weather conditions during the day.

Ice climbers are often exposed to being hit by avalanches from above (Figure 2) and this requires a different approach to avalanche safety than traditional avalanche education provides, where human triggering is a primary focus. In addition to triggering avalanches themselves, ice climbers also need to make judgements about the likelihood of natural avalanches releasing above them and how far they may run. Predicting natural avalanches is highly uncertain and has more in common with highway avalanche forecasting than it does with backcountry recreation. As well, public

avalanche forecasts are often biased towards human triggering for skiers, rather than forecasting for natural avalanche release.

Professional avalanche operations at ski resorts, transportation corridors and mechanized skiing all maintain detailed terrain data in the form of an avalanche atlas. This is crucial reference material that captures historic patterns of avalanche activity, along with geographic data and visual references. This information has often been collected for decades, and the data facilitates accurate estimates of avalanche frequency and runout distance. This is not the case for ice climbs where until now, nobody has systematically collected avalanche information.

Despite not being recorded, the avalanche history and information usually exists for popular routes and is often well-known within insider groups. Experienced local climbers and professional guides have spent decades climbing these routes and possess deep knowledge of the terrain and patterns of avalanche activity. The surveys are a way of engaging the broader community to solicit their knowledge, and get more people involved in the discussion and the learnings. Everyone has valuable information to share through their observations and they don't need to be an expert to add to the conversation.

The ice climbing avalanche atlas is then a starting point to provide climbers with the historical knowledge and information to better judge the frequency, timing and location of avalanche

activity on specific routes. Combined with conditions reports, public avalanche forecasts and real-time remote weather station data available at www.avalanche.ca, climbers can now access a comprehensive information stream to inform their choices about where and when to climb.

8. ACKNOWLEDGEMENTS

Thank you to Cam Campbell, Nancy Geismar, Pascal Haegeli, Tim Haggarty, Ian Jackson, Conrad Janzen, Mike Koppang, Steve Holeczi, Grant Parkin and Sarah Taylor as well as the local climbers, ACMG/AMGA guides and all those who completed the surveys - thank you for contributing your experience.

9. REFERENCES

- Canadian Avalanche Association (CAA): Technical Aspects of Snow Avalanche Risk Management - Resources and Guidelines for Avalanche Practitioners in Canada (C. Campbell, S. Conger, B. Gould, P. Haegeli, B. Jamieson, G. Statham Eds.). Revelstoke, BC, Canada, 2016.
- Jamieson, B., Haegeli, P., Gauthier, D. : Avalanche Accidents in Canada. Volume 5. Canadian Avalanche Association. 432 pp. 2007.
- Josephson, J.: Waterfall Ice Climbs in the Canadian Rockies. 3rd ed. Rocky Mountain Books, 272 pp. 1994.
- Holeczi, S., Statham, G.: Polar Circus Avalanche Response, February 5-11, 2015. International Snow Science Workshop, Breckenridge, USA, 2016.
- Sole, A.: Waterfall Ice Climbs in the Canadian Rockies. Rocky Mountain Books. 92 pp. 1980.
- Statham, G. and Campbell, C., (in press): The Avalanche Terrain Exposure Scale v.2. International Snow Science Workshop, Bend, USA, 2023.