

Persistent Weak Layers and the Winter of 2009-2010

By: Karl Klassen, March 25, 2010

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Introduction

As in the last two winters, backcountry users in western Canada are faced with persistent weak layers in this year's snowpack in many regions of the province. This discussion is intended to augment CAC Avalanche Forecasts which provide information about the locations and current condition of these layers, to help you better understand how these layers formed, and to discuss the challenges related to managing this type of avalanche problem. It provides general guidance and some tips to help you ask the right questions and gather information that can help you make an informed decision.

I must stress there is no 100% guarantee of safety in the mountains. You could be caught in an avalanche, injured, or killed even if you follow every piece of advice in this discussion and "do everything right." That said, avalanche accidents are preventable—it's up to you to get the training, information, and appropriate equipment to properly manage your risk if you choose to go into the mountains.

This discussion is for recreational backcountry users. Professionals follow a strict hazard assessment and risk management process that provides the foundation for their decisions and actions.

Surface hoar PWLs are known or suspected to be the failure layer in all fatal accidents so far this year.

This season's snowpack is currently a complex risk management problem and will likely remain so for some time to come. The snowpack this year is not something to mess with or take for granted.

My intention is not to scare people out of going into the mountains. It is possible to manage risk, maintain reasonable margins of safety, and make informed decisions in the conditions we are currently experiencing. But my personal approach to a snowpack like this one is very different than when there are fewer or no PWLs involved. Local knowledge of the snowpack and experience with similar conditions are critical components in managing risk this winter. A high level of training and experience are required to tackle large pieces of terrain in a PWL winter.

The most important factor in managing risk in these circumstances (and, in my personal opinion, at all times) is making terrain choices that are appropriate for the snowpack on the given slope. To do that you need to have a full understanding of avalanche terrain and know how to utilize it effectively. You can learn about terrain by taking an Avalanche Skills Training (AST) course that follows the curriculum established by the Canadian Avalanche Centre. More info on AST courses at <http://www.avalanche.ca/cac/training/ast>.

A good starting point is the CAC [Online Avalanche Course](http://access.jibc.bc.ca/avalancheFirstResponse/index.htm) found at: <http://access.jibc.bc.ca/avalancheFirstResponse/index.htm>

Your comments, questions, and thoughts are welcome. You can reach me at: kklassen@avalanche.ca

What's the problem?

A persistent weak layer (PWL) is so called because it does not strengthen over time, and in some cases it even becomes weaker over time. A PWL can remain unstable for weeks or even months and is often the cause of avalanches long after it originally forms and is buried.

Experience has shown that PWLs go through cycles where periods of high avalanche activity are interspersed with periods when few avalanches occur. When, where, and why these cycles occur can be difficult to predict with a high degree of accuracy. Unstable periods are often related to changes in weather such as snowfall, wind transport of old or new snow, rain, temperature changes (especially from cold to warm), and solar radiation. A PWL that has produced avalanches and then shows signs of stability is generally treated with scepticism by knowledgeable practitioners, most of whom describe such a layer as dormant rather than stable, the assumption being (as Monty Python once said): "...it's not dead, it's just sleeping."

This year's PWLs are mostly surface hoar layers. Surface hoar is discussed near the end of this paper.

Managing The Risks Associated With PWLs

Terrain Choices

PWLs are associated with high uncertainty and low confidence. With PWLs I don't ask: "Will it slide?" I do ask: "When it slides, what will happen to me or my partners?" This approach leads to greater margins for error, which in my opinion, is the best way to manage risk at times and places where confidence is low. With PWLs, I am extremely careful in choosing what terrain I use, when I go there, and how I manage my groups. Here are some general tips for managing risk at any time and some specific ideas for dealing with the PWLs in general and the specific PWL problems we face this season:

- DO NOT stop, regroup, or park in avalanche paths.
- DO stop, regroup, or park only in safe areas where avalanches will not start or run through/over:
 - High points.
 - Ridges above start zones.
 - Dense timber well away from the track or runout zone.
- Eliminate or minimize exposure to terrain traps, such as:
 - Depressions
 - Gullies
 - Creek beds
 - Sudden transitions from steep to flat (lakeshores, benches, road cuts, etc.).
 - Slopes where an avalanche might carry you:
 - Over a cliff.
 - Into trees.
 - Against obstructions such as rocks or boulders.
- Take a more conservative overall approach in areas where this year's PWLs are more prevalent. Find out where they are a problem by checking the information at: <http://www.avalanche.ca/cac/bulletins/regions>.
- If you must travel in or through start zones or tracks, go one at a time from safe spot to safe spot.
- Go one at a time or spread out when travelling in or through avalanche runout zones.
- Take a more conservative approach at Treeline and Alpine elevations.
- Avoid slopes that have rocks and scattered trees sticking out of the snow.
- Avoid unsupported terrain features especially if there is a pronounced convexity (roll).
- Stay on low angle slopes that are less than 30° incline.
- Stay on [simpler terrain](http://www.avalanche.ca/cac/library/glossary/a-z?index=A-ATES) ([http://www.avalanche.ca/cac/library/glossary/a-z?index=A - ATES](http://www.avalanche.ca/cac/library/glossary/a-z?index=A-ATES)).
- Avoid avalanche start zones and tracks if possible.

Using Your Experience

The PWLs of the last couple of years and this season so far are producing avalanches that are beyond the experience of many people. I have been in the avalanche business for over 30 years and every week for the last six weeks I've been seeing things I have never seen before. Check the photos in our [avalanche photo gallery](http://www.avalanche.ca/cac/library/avalanche-image-galleries/feb-march-2010) (<http://www.avalanche.ca/cac/library/avalanche-image-galleries/feb-march-2010>) to get an idea of what's been going on (and is still going on at the time of this writing). We have seen many surprises including:

- Avalanche starting on unusually low angle terrain (as low as 15 – 20 degrees in some cases).
- Running much farther than people expect (if you have never seen a size 3 or 4 avalanche for real, you will be blown away at how far and wide they run).
- Being triggered from far away (often from 100 metres away but in extreme cases from hundreds of metres away). If you trigger one from the bottom or middle of a slope and it comes down on top of you, you will be caught and if it's a big one, you will likely not survive.

If you are thinking "I've been riding here for 30 years and have never seen an avalanche on this slope before," think again.

If you are thinking "This is a low angle slope," think again.

If you are thinking "An avalanche will not run this far," think again.

Human Factors and PWL's

In my experience, a significant proportion of serious accidents involving PWLs occur in late winter and spring on blue-sky days. I suspect there are a number of factors at play:

- It takes at least several days for PWLs to adjust to stress from new snow or wind events. People don't wait long enough after a storm before they push out on a nice day.
- It takes at least a couple of days for most non-persistent, storm snow instabilities (which might trigger a step-down avalanche) to settle out. People don't wait long enough after a storm before they push out on a nice day.
- On clear days, warming and solar radiation can quickly destabilize slopes or cornices above, which then trigger a PWL or a step-down avalanche. People don't look up enough, and they tend to underestimate the strength of the sun when assessing warming and solar radiation on slopes or cornices far above, especially if they are in the shade in the valley below or on a "cold" slope such as a north or east aspect.
- There's less tendency to stop and reassess current, local conditions in good weather. People miss changes happening around or above them.
- People are more willing to push into bigger, steeper, more complex terrain when the weather is good.
- People ride more aggressively on blue-bird days.
- People tend to discount their intuition or "gut feel" more on blue bird days. If something doesn't feel right, they are more willing to push on a clear warm day than on a cold, foggy, snowy day.

In addition, there's some kind of dynamic that encourages people to make poor decisions when they are in large groups. Perhaps:

- There's a false sense of security that comes with being in a group that's all doing the same thing in the same place at the same time.
- Less experienced people in the group assume that there is someone more experienced who knows what they are doing and will ensure things are safe.
- People are unwilling to speak about their concerns or worries in front of other people.

If any of the above factors is at play, and especially if more than one are a potential, you should very carefully examine your motivation for exposing yourself to slopes where PWLs are known or suspected to exist. It is strongly recommended you back off and go to slopes where PWLs are not an issue. Or choose low angle, simple terrain that is not exposed to slopes above.

PWLs are among the most difficult of all avalanche problems to assess, predict, and manage. Even with extensive training and over 30 years professional experience, I struggle with the combination of "low probability-low frequency-high consequence." That is, it's often difficult to trigger a deeply buried instability and the number of avalanches you see is low, but the consequences if caught in a deep slab avalanche are very serious due to the size and mass of the slide. The answer lies in making decisions based on what you know about a slope, its history of avalanche activity over the season, slope use patterns (e.g. compaction), and/or stabilization (avalanche control) measures. In the absence of such knowledge or without the training to properly assess the information that is available to you, the only reasonable way to manage your risk is by leaving a wide safety margin wherever a PWL is known or suspected.

It's important to be aware of the potential risks so you can make an informed decision when determining whether the risks are acceptable to you and your party. There are a number of steps you can take to ensure you are making an informed decision:

- Examine your own motivation and that of others in your group. Check out [this article](http://www.mec.ca/Main/content_text.jsp?FOLDER%3C%3Efolder_id=2534374302881868): http://www.mec.ca/Main/content_text.jsp?FOLDER%3C%3Efolder_id=2534374302881868
- Assess the training and experience of your party.
- Use a decision making process or tool like the [Avaluator™](https://www.avalanche.ca/cac/pre-trip-planning/trip-planner) to aid in trip planning (<https://www.avalanche.ca/cac/pre-trip-planning/trip-planner>).
- Ensure all members of the party play an active role in all aspects of planning, preparation, and execution of the trip.
- Don't depend on someone else to make decisions for you. Ask the leader(s) of your party about their level of training, experience, and current local conditions. If in doubt, turn around and go back.
- Talk to the others in your party. Listen to what they have to say. Respect their concerns. Make sure lines of communication remain open between all members of the party at all times.
- Use the information in this discussion and from regional avalanche forecasts to assess general conditions for the area where you will be.
- Talk to credible local experts such as guides and avalanche professionals to get a handle on local conditions.
- Watch for signs of instability while travelling, such as [whumpfing](#), cracking, and avalanches on similar slopes. These observations give you a clear signal that things are at a critical state. However in the case of a known or suspected PWL, the absence of whumpfing or avalanches should never be interpreted as evidence that a layer is not active.

The Characteristics Of PWLs

Reactivation or Triggering

Dormant persistent weak layers tend “wake up” or reactivate when:

- *Large triggers are applied.*
Cornice fall triggering is common. Sleds are bigger triggers than skiers. A sledder or skier jumping onto a slope is a bigger trigger than one who is not jumping.
- *Step-down avalanche potential exists.*
Weather factors such as new snow, rain, wind, temperatures, and solar radiation are common triggers for storm snow or surface avalanches, which then step down to PWLs.
- *Rapid, significant new snow loads are added.*
I hesitate to suggest a general rule but 30cm in 12 hours is certainly something to think carefully about.
- *Rainfall adds warmth and load to the snowpack.*
Any amount of rain is of concern if the existing snow is dry. Things might hold up a bit better if the snowpack is a thick crust or very firm old snow that has been previously warmed or melted and refrozen.
- *Wind is loading snow onto a slope.*
Even relatively small snowfalls can accumulate quickly and deeply when wind starts moving snow around. It's not at all beyond the realm of possibility that a 5cm snowfall could accumulate a 50cm deep slab within a few hours in a windloaded area. Remember that windloading occurs not only on leeward slopes but also in pockets on crossloaded or even windward slopes.
- *Temperatures rise rapidly.*
Three degrees C in an hour would be something to watch, especially starting at -10 or warmer and more so if temps are getting close to or going above the freezing point as they rise.
- *Strong solar radiation affects a slope.*
The snow need not feel wet or slushy for it to become unstable. Remember that solar radiation is often stronger and hits earlier on high elevation slopes. Even on a shaded north or east facing slope, solar radiation can be a factor if the backside of a cornice has the sun shining on it at ridgetop.

If more than one factor exists on a slope at any one time, the effect is greater than the sum of its parts.

The potential for large step-down avalanches

We currently have multiple persistent weak layers in the snowpack, the most common ones being surface hoar layers dated January 24th, January 30th, February 8th, February 24th, and March 8th (all dates are subject to variation depending on which area of the province you are in). These are all in the upper 150-200cm of the snowpack. With this kind of layering a smaller slide involving shallower weak layers could impact an area where a deeper weak layer exists, subsequently triggering a failure in the deep weak layer. While this situation is not limited to persistent weak layers, it's of particular concern when there is a PWL in the snowpack and a deep slab avalanche is possible, because:

- Persistent weak layers are often buried very deeply in the snowpack so there's a lot of snow available to avalanche.
- Deeper avalanches usually involve hard to very hard layers of snow that can propagate over very wide areas and across terrain features that are normally considered safe. I clearly recall a PWL from November (1996 I think?) that failed in March and propagated from ridgecrest in one alpine bowl around a very pronounced ridge, then ran down below treeline and back up into the alpine in an adjoining bowl. The entire fracture line cleaned out both bowls as well as the terrain between them and was over 2000m in length. The debris took out mature trees in two separate drainages. You could smell freshly broken timber from the helicopter as we flew over the valley bottom!
- When and where multiple persistent weak layers exist providing step-down potential is hard to predict. Unless you are completely familiar with the entire winter's history of a slope it's impossible to tell whether there's a PWL step-down potential.

We are definitely in a winter where step-down avalanche potential currently exists and probably will remain a concern for the rest of the season.

What is surface hoar?

The majority of this year's problems involve surface hoar. To make a long story short, surface hoar is the winter equivalent of dew. It forms in calm, cool conditions and is associated with clear skies, although local fog banks enhance formation of surface hoar when skies are clear above the fog layer.

Surface hoar is most easily observed when it is still on the surface of the snowpack. Although it's found in a variety of forms, classically it's a glittery, icy-looking crystal with a feathery shape. It can be very small (a millimetre or two) to very large (as big as 100mm or more). Once buried, surface hoar grains (especially smaller ones) can be much harder to find and identify. They sometimes lie flat and form an extremely thin layer that even experts have a hard time seeing, and sometimes they become mixed with other grains from layers above and below making them difficult to pick out. Surface hoar tends to form a more unstable layer when:

- It has a feathery shape (although one should not write off other common shapes such as needles or cups, especially if the following conditions occur).
- There are many crystals packed closely together.
- The underlying surface is firm, hard, and smooth (e.g. wind or especially sun crust).
- New snow does not penetrate into the pore spaces between the surface hoar grains.
- There is a slab of cohesive snow on top of the layer. Be careful here, especially when new snow is warm and there's a lot of it, slab properties can occur in layers as soft as four finger resistance (good powder riding conditions). One of the biggest avalanches I was personally caught in involved a 100cm deep slab with a fracture line 300m wide on a 23 – 26 degree slope. Ski penetration was 80cms and riding conditions were excellent; we were getting face shots in what felt like bottomless powder. This was one of the scariest days of my life which taught me never to underestimate the potential instability of surface hoar layers and to never assume that snow quality alone is a reliable indicator of slab characteristics.

Surface hoar often forms in pockets; conditions might be right on one part of a slope while just a few metres away, they are not. Surface hoar is easily destroyed when exposed to sun or wind; one part of a slope might be affected by wind or sun while an area nearby is sheltered. This often makes for highly variable distribution of the layer. Once buried, surface hoar is one of the most persistent of all weak layers.

In the case of this year's snowpack, almost all the surface hoar layers are widespread although at the current time they are most active on cool to cold slopes (NW, N, NE, E aspects) above about 1800m elevation.