Aspen Highlands Snow Safety Plan
Revised January 2022

The Aspen Highlands Snow Safety Plan is comprised of a collection of separate documents.
Overview of the Snow Safety Plan
Avalanche Rescue Plan
Explosive Training Manual
Basic Concepts of Snow Safety Field Work
Safety Plan of Snow Safety Department

Overview of the Snow Safety Plan

Introduction

Aspen Highlands Snow Safety Plan addresses avalanche hazard identification, avalanche risk assessment, snow management, avalanche risk reduction, and avalanche rescue within the Aspen Highlands Special Use Permit area. This plan is implemented by the Aspen Highlands Ski Patrol (AHSP) under the direction of the Snow Safety Department.
Our goal is to provide our guests with a safe skiing experience in the steep terrain within the operating ski area boundary.

Scope of Responsibility

The plan covers the terrain specified by Aspen Highlands Ski Area Special Use Permit. It also addresses lands adjacent to the operating ski area which may be accessed by the public using Aspen Highlands lifts.
AHSP has no responsibility for avalanche risk identification, reduction or rescue beyond the operating ski area boundary. However AHSP may, when requested by the Pitkin County Sheriff, assist in rescues beyond the boundary.
Additionally, AHSP has no responsibility for avalanche hazard identification, risk reduction, or rescue outside of normal operating hours (i.e. dawn to dusk) within the operating ski area boundary, or outside the bounds of the ski season (December 1 – April 25 approximately)
AHSP reserves the right to conduct avalanche hazard identification and risk reduction operations at any time within the ski area permit boundary from the time of first snowfall until the final melting of the seasonal snowcover.
Finally, this plan is a work in progress, is subject to revision at any time, and is intended to serve as a guideline and training document only, and is not a description of a standard operational plan.

Structure of Department

The Aspen Highlands Snow Safety Plan will be implemented by the Aspen Highlands Ski Patrol (**AHSP**) lead by the Snow Safety Department. This department consists of a Avalanche Program Director, a Avalanche Program Assistant Director, and two Avalanche Technicians. The Avalanche Program Director reports to the Ski Patrol Director. The Avalanche Program Director supervises the department. The Snow Safety department is in charge of patrollers during avalanche risk reduction operations. AHSP consists of approximately forty patrollers both full and part-time with approximately twenty-four patrollers on duty on any given day.

Avalanche Hazard Identification

Identifying avalanche hazard and assessing avalanche risk is a complex task. It requires a field worker to assimilate relevant information from a variety of sources and formulate an assessment based on experience, intuition, and local knowledge of the area. The three main categories of information are terrain, weather, and snowpack.

Analyses of terrain, weather, and snowpack are an integral part of avalanche hazard identification. .

Terrain Analysis

Terrain analysis is an important element of avalanche hazard identification. Aspect, elevation, slope angle, terrain variation, ground cover, and convexities all play a role in a path's avalanche potential. Furthermore, exposure, tree cover, density of tree cover and fetch need to be considered.

At AH, a considerable amount of work has been put into the creation of an atlas of all avalanche paths within the ski area permit boundary, and of significant paths adjacent to the area. Over 200 avalanche paths and/or bank slides have been cataloged within the operating ski area. Statistics of each path are listed in a spreadsheet computer file S:\AH-Snow Safety \weather and avalanche history oj\avalanches\pathstat2021.xls.

The avalanche path atlas is used to aid in terrain analysis, as a teaching tool, and as part of the overall database. Copies may be found in the Snow Safety offices and is considered to be a companion document to this Snow Safety Plan. A Google Earth version of the atlas is available on the S drive of the company computer network. S:\AH-SNOWSAFETY\weather and avalanche history oj\Google Earth files\Atlas\Aspen Highlands Ski Area.

Weather Collection and Analysis

Collection of weather data, and the analysis of this data are an important part of our snow safety program.

Meteorological data is considered Class III information according to The Avalanche Handbook. However, our database helps us to establish and recognize what conditions are normal. The normal range for each weather parameter is closely monitored as well as the combination of various parameters. While we have not developed a computer model specific to our area, we do have a very good idea of when we approach the limit of our range of experience. Whenever a weather event is unusual we pay special attention.

Weather Collection

Weather observations should be complete, accurate and recorded in a uniform manner, and made routinely.

Aspen Highlands Avalanche Program follows the recommendations of the American Avalanche Association as published in the 2010 edition of Snow, Weather, and Avalanches: Observation Guidelines for Avalanche Programs in the United States. (SWAG)

At AH we have five automated weather stations which use Campbell Scientific equipment Jerome Park, Cloud 9, Loge Peak, Highland Peak, and North Woods.

Additionally, manual new snow, total snow and snow water equivalent readings are taken each morning, as is a sky cover observation at the Cloud 9 study plot. A study plot at North Woods is also maintained.

Weather database

Comparing current weather and snowpack conditions to past storms and weather patterns improves planning and operations.

Westwide type data base

Our primary weather database is stored in a spread sheet format compatible with the Westwide data network which has been widely used in the United States since 1968. Each record contains data that summarizes a 24 hour period with entries in over 20 categories. Maximum and minimum air temperatures, new snowfall, total snow, snow water equivalent, six hour averages of wind speed and direction are some of the principle elements in each record. We have compiled this information for over thirty years.

Snowpack Analysis

Snowpack analysis is undertaken at AH using several methods. Full data snow profiles have been done monthly at the Cloud 9 study plot since 1995. A number of snow profiles have also been done at the North Woods study plot.

Test profiles are done periodically in many areas of the ski hill. These profiles may or may not be recorded and kept in annual records.

Data obtained from these profiles may include total snow cover depth, grain identification, layer identification, relative densities (hand hardness), densities, snow temperatures, air temperature, snow water equivalent, ram penetrometer results and subjective instability test results.

Specific data obtained in a given snowpit will vary with the purpose of the pit and the time of year. These snowpit profiles help to identify and track weak layers imbedded in the pack, and aid in understanding the unique seasonal metamorphism of the snowpack each year.

Snowpack data is categorized as Class II data in The Avalanche Handbook. It is important for field workers to learn how to dig a snowpit. It would be difficult to understand snow and snow physics without interacting with the snow. Observing and measuring and recording information about the snow indirectly contribute to a field worker's understanding. Certainly, digging many snowpits over the years helps field workers converse intelligently with other field workers about the snow.

Instability tests, especially, can yield useful information when performing a stability evaluation. However, we do not rely on results from these tests in the snow pits to direct our actions. We prefer to thoroughly manipulate the snow cover in all of our starting zones and seek Class I information by using explosives and ski testing.

Avalanches occurrences

Avalanche occurrences have been recorded since 1969 at AH. It is difficult to gage the completeness, consistency, and accuracy of the database.

From 1969 until 2008 avalanche occurrences followed the format recommended by the Westwide network.

2008 to present, the avalanche occurrences database adheres to the SWAG guidelines

SWAG using both the relative and destructive force size classification systems. The destructive force scale gives a good absolute magnitude which is useful for field workers not familiar a particular avalanche path. However, it is difficult for field workers to estimate the destructive force of a particular avalanche, and the destructive size scale is often applied inconsistently. It is more objective to record the vertical fall, depth of crown and width of each avalanche to convey the size of an event.

Google Earth Avalanche Files

In the summer of 2012 a file of some noteworthy avalanches began to be compiled in Google Earth format. S:\AH-SNOW SAFETY\weather and avalanche history oj\ google earth files\avalanches

Snow Management Program

We live in a continental climate, where early season snowpacks are typically shallow and weak. Shear plane disruption and compaction of the basal layer near the ground early in the season are important to build a strong foundation in the snowcover for the entire season.

After the initial disruption of the basal layers it is important to affect each successive layer of snow as it forms. Persistent weak layers often form at the snow surface. Whenever these weak layers become buried by subsequent storms, they have the potential to become shear plane pathways for propagating cracks, (or anti-cracks). Therefore, it is important to disturb each layer of new snow while it is near the surface. In others words, all slopes should be skied after each storm. Opening terrain to the public is the most effective means of accomplishing this goal. However, there are limitations. Just because a slope is open to the public, does not mean it will receive sufficient disruption. Areas near rocks and logs sometimes are avoided by most skiers. Close attention must be given the amount and distribution of the skier traffic. Pockets suspected of receiving too little skier traffic can be dealt with by follow-up ski packing, bootpacking, or use of explosives.

Our primary approach to snow management is "early and often" shear plane disruption. Stability evaluation and avalanche forecasting is secondary to a thorough and ongoing effort to manipulate the snowcover. We try to affect each and every starting zone within the operating ski area. Thoroughness and redundancy are key components of our snow management program. Even after initial layer disruption and ongoing manipulation of the snowpack, we will continue to use explosive testing to verify the lack of instability in the snowpack.

Instability can only be confirmed by the presence of shooting cracks or avalanches occurring. Instability also varies over time and space. For these reasons, negative results from explosive testing can never conclusively show that there is no instability. Therefore, residual risk is always present.

Snow behaves in accordance with the laws of physics. Therefore, we expect the snow to behave in a similar manner given similar conditions. This is why we maintain a weather and avalanche database. We try to understand how patterns of weather and snowpack interact. By knowing where and when, we have had avalanching in the past, we stand a better chance of recognizing similar conditions that can lead to avalanching in the future. By continuing to go into the field, day after day and year after year, we can build a very specific experience base. The more we pay attention, the better are our chances of being successful.

A problem arises from the fact that each situation has a huge number of variables, and any number of these variables may interact with each other in a variety of ways. Experience and education help us to derive patterns in the variables. But it is an ongoing challenge to identify all the relevant variables and to assign each its proper weight in terms of importance. This uncertainty is one of the things that make snow safety work so interesting and challenging. It is never exactly the same.

Another key objective of our "early and often" disruption of the snow layers is to keep the snow on the slope. If we do not begin our snow manipulation early enough in the season we stand a chance of losing the first few storms worth of snow. There is a wide variation in the timing of the first snowfall each season, and thus it is a challenge to schedule the beginning of bootpacking. You never know once the snow begins to fall whether it will continue or you will have an extended dry period. Some years we have abundant snowfall and the slopes fill in quickly even after early season avalanching. Other times like the 2011-12 season we are left wishing we had not lost the precious early season snowfall. (Wind events can also greatly affect the efficiency of our bootpacking program. If we can pack the snow before the wind scours or densifies the snow into slabs, layer disruption is much easier. It is more difficult to bootpack when there is a hard wind slab in place.

Daily Operations

When the ski area opens to the public for the season, daily operations commence. Each day we collect and analyze weather data, check the weather forecast, and make field observations in order to formulate a daily plan.

We get daily weather forecasts from the National Weather Service, Aspenweather.net, as well as from the CAIC. Some days it is necessary to run avalanche risk reduction routes before the ski area is opened to the public.. See "Typical Situations" for examples of possible daily action plans.

Daily operations continue to emphasize, monitoring the amount and extent of snowcover manipulation in all of the starting zones within the operating ski area. We attempt to identify the pockets which need additional work and take appropriate action. We continue to ski pack, bootpack and use explosives throughout the season.

Daily operations may also include a variety of other activities including digging snowpits, terrain familiarity tours or ongoing training.

Another aspect of daily operations is sharing and exchanging pertinent information about the snowpack and avalanche activity with the CAIC and neighboring avalanche programs. We interact with programs at Aspen Mountain, Aspen Mountain Snowcat Tours, Snowmass as well as Aspen Expeditions.

Avalanche Risk Reduction Techniques

The following techniques are used at AH for avalanche risk reduction. These techniques can be combined or used separately. As each situation is unique, techniques will be chosen to fit the situation. This list is by no means complete; and new, modified, unlisted or combined techniques may be used at any time.

Closures: temporary or permanent
Shear plane disruption/compaction: boot and ski packing, SAE, and ongoing skiing
Ski Testing or cutting
Explosive Testing: hand charges, large ANFO shots or avalauncher shots
Avalanche snowpack disruptor roller

Closures

Temporary closures can vary greatly. Slopes may be closed for a matter of hours while we test for instability, or slopes may be closed the entire season.

Permanently closed areas include: Loge Bowl, sections of Child's Play, the Grey Area, Y10 and Y11, the area between Y14 and Canopy Cruiser, the Eden area, the G-P's, the Twilight zone, sections of Sherwood Forest, and the area between U-S 3 and Sepporator.

Shear plane disruption and compaction techniques

We use these techniques in virtually all of the avalanche terrain at AH. In order to achieve the desired level of layer disruption and compaction requires an extensive amount of resources and effort. In recent years we have performed over 6500 man hours of bootpacking and we have used an average of 3000 hand charges of explosives each season.

Bootpacking
For a detailed description of our bootpacking program refer to the paper presented by Karen Sahn at the ISSW in 2010. Link below:http://arc.lib.montana.edu/snow-science/objects/ISSW_O-058.pdf

ISSW 2010 Ksahn bootpacking http--arc.lib.montana.edu-snow-science-objects-ISSW_O-058.pdf.url

Ski packing
Depending on the time, the place and the snow conditions, ski packing may be the technique which provides the most efficient and best means of layer disruption and compaction.
Mechanical packing
Winch cats and a system of rollers may be a good way to achieve shear plane disruption and compaction in the future. Methods, techniques, and machinery for expanding mechanical packing are being considered.
Strategic Application of Explosives (SAE) (Carvelli, 2008) http://arc.lib.montana.edu/snow-science/objects/P__8016.pdf

ISSW 2008 Peter Carvelli Bootpacking http--www.issw2008.com-papers-P__8016.pdf.url

Ongoing skiing
Opening terrain to the public is a good way to disrupt the surface layers of the snowpack. The number and distribution of this skier traffic must be closely monitored to decide where and when to augment ongoing skiing with other shear plane disruption techniques. If skiers are avoiding certain pockets in the starting zones for whatever reasons additional manipulation of the snow cover is required.
If ongoing skiing is required before the lifts are scheduled to open to the public for the season, we make every effort to ski all of the untracked powder ourselves. When this is not possible, we use our "powder posse" program to accomplish the ongoing disruption of snow surface layers.

Ski Testing or cutting

Certain conditions allow slope stability to be tested by ski cutting across the slope. Ski testing should not be used if deep slab instability is suspected. Ski cutting may be appropriate if the goal is to test for instabilities in snow layers near the surface. The consequences of triggering a slide should be taken into account before using this technique. Are you expecting widespread signs of instability (collapsing or shooting cracks) in ten centimeters of low density new snow or is the most likely potential for instability in isolated pockets of dense wind slab? Many factors working together determine if ski cutting is an appropriate technique.

Explosive Testing

Explosive testing in the starting zones gives us direct information about instability. This Class I data is most valuable is forming a stability evaluation. However, it is important to continue to point out negative results from explosive testing does not necessarily mean the entire snowpack is stable. Information that reveals instability is the most useful.
Explosives used may range in size from 1 kilogram to over 20 kilograms, and the number of explosives used may be small or large depending on each unique situation.
Large explosive tests are more common in the afternoon to allow an overnight waiting period before the slope is open to the public.

Two avalaunchers are available and may be used when and where the situations require. The main advantage of using an avalauncher is to deliver explosives from a remote location without having to send control personnel into the starting zones. This can be a useful first step, when deep slab instability is suspected.
Explosive testing is an integral part of both early season and ongoing snow safety operations.
Explosive testing may be used prior to bootpacking to protect packers and/or to affect wind slab or deep impenetrable snow.
Explosive testing may also take place after initial layer disruption to test the slope prior to opening to the public for the season. A 24 hour waiting period between using explosives and opening to the public is most common during this phase.
During mid-season, explosive testing is carried out routinely after each loading event in many avalanche paths to test the instability in the new snow layer near the surface. If there is sufficient layer disruption and compaction and deep slab instability is a only a very remote possibility, there may not be a 24 hour waiting period between explosive testing and opening the slope to the public.
Fracture toughness cannot be measured and weak zones cannot be precisely identified. Residual risk is always present. Explosive testing helps to lessen this residual risk.
"We will never be smarter than the snow" as Peter often said. Therefore, redundancy and ongoing explosive testing continues to be a mainstay of our snow safety program.

See Aspen Highlands Explosive Storage and Use Guidelines for details.

Education

Field experience alone is not enough to consistently make good decisions. Evaluating instability and assessing risk must also be grounded in an understanding of scientific principles. For this reason we rely heavily on a targeted education for our field workers.
The Avalanche Handbook written by David McClung and Peter Schaerer, 2006 edition is an excellent source for learning and understanding the fundamentals of snow science.
Field experience combined with targeted education and objective reasoning helps forecasters and patrollers to make good decisions about snow instability.
Personnel from Aspen Highlands have attended the ISSW, CSAW, Avpro, AIARE avalanche courses, American Avalanche Institute courses, as well as in house training and other reputable avalanche schools including the National Avalanche School.
Snow Science Papers Library. There is an extensive array of snow science research papers available in the snow safety office and online. An ongoing discussion of snow science related topics is encouraged.

Training

All patrollers participate in avalanche rescue training which includes but is not limited to: transceiver practice, hasty search procedures, larger scale rescue ops, safe travel, probing and debris shoveling. Training is ongoing throughout each season.

Record Keeping

The Snow Safety department keeps records of weather data, snowpit profiles, avalanche occurrences, avalanche risk reduction work, ski and boot compaction and explosive use. Whenever avalanche risk reduction routes are run, the snow safety leader fills out a control route log which lists the route team assignments. Each route team completes a route log which shows explosive use and ski cutting activity.

Rescue

AHSP is responsible for avalanche rescues within the operating ski area. Additionally, AHSP may be called upon to lead or aid rescues outside the operating ski area by the Pitkin County Sheriff Office (PCSO). Participation in these “out of bounds” rescues is not mandatory, and will be decided upon by the Patrol Director and the Snow Safety Director with primary consideration given to the safety and well being of ASC personnel.
See Aspen Highlands Avalanche Rescue Plan for details.

Mission Statement

The mission of the Aspen Highlands Snow Safety Department is to:
Open avalanche prone terrain in a safe and timely fashion.
Focus on safety: personal safety; team safety; public safety
Identify avalanche hazard and assess the risk
Determine the most effective methods to reduce avalanche risk and take appropriate action.
Monitor weather, snowpack, and terrain throughout the season.
Acquire knowledge through experience and targeted education.
Build on the strong foundation put in place by the people who came before us
Respect our surroundings, our peers, our guests.

Flexibility and Evolution

As we gain experience and acquire new knowledge, techniques may evolve, change, or be discarded. Various tools may be used more, or less or not at all. New tools may be acquired. Systems may evolve or be replaced with other systems. Forecasting may be rules based at times, intuition based at times, flow based at times. Risk Reduction Operations may flex to match each unique situation in a non-linear fashion. The department will be run dynamically, striving to learn more, grow stronger, think creatively, and work safely. Techniques, tools, personnel and systems will flex and evolve.