ADVANCED

AVALANCHE

AWARENESS

ADVANCED AVALANCHE AWARENESS

The printing of this course material resulted from a concensus of opinions, formed at the Advanced Avalanche Awareness Course, run for Instructors at Golden and Rogers Pass, B.C. on May 4th to 6th, 1984.

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ADVANCED AVALANCHE AWARENESS COURSE

FOR THE WINTER RECREATIONIST

Canadian Avalanche Association
Education Committee
November 1984

ADVANCED AVALANCHE AWARENESS COURSE FOR THE WINTER RECREATIONIST

A. INTRODUCTION

1. Course Objectives

To promote safety in winter mountain recreation through increased awareness of avalanche phenomenon. Theory and technique for understanding snowpack stability and evaluating avalanche hazard will be taught in classroom sessions. Field trips will demonstrate safety procedures, physical tests and decision making criteria that will give the participant an advanced level of experience in many facets of avalanche safety. The necessity of careful observation, logical thought process and responsible leadership and decision making will be stressed in class and field sessions.

2. Target Group

Non-professional leaders of outdoor groups, cross-country skiers who make mountain tours, downhill skiers who ski powder fields, snowshoers, ski-dooers and climbers who practice their sport in the mountains of Western Canada in winter.

3. Duration

Sixteen hours classroom time and 24 hours of field trips in mountainous, avalanche prone terrain. The course is designed to be run over a four day time frame. This may take the form of two consecutive weekends to accommodate the target group.

4. Student Prerequisites

All participants should be reasonably fit, able to travel competently over snow in mountainous terrain, and have adequate equipment and clothing to participate on day long field trips in winter weather. Previous avalanche awareness training is required.

5. Equipment

Oversnow travel equipment may vary with the interests of the target group.

Prepare a mailout equipment list, as required. Each students personal equipment will include the following materials. Instructors must be prepared to provide these materials for all participants use as most people will not own or have access to this specialized equipment.

- rescue beacon (2.275 kHz. compatible)
- probe
- shovel
- 8X hand lens
- crystal screen
- hand thermometer (-40°C to +50°C)
- waterproof notebook
- metric folding ruler
- pencil(s)

The above may have to be supplied by the instructor at cost.

For instructors <u>add</u>:

- first aid kit
- compass
- inclinometer
- snow saw
- altimeter

6. <u>Instructor Ratio</u>

Suggest a maximum classroom attendance of 24 students, 18 or less is preferred. Field trips must not exceed eight students per instructor to ensure personal instructor/student interaction and optimum knowledge transfer.

7. <u>Instructor's Credibility</u>

Your status as an effective instructor requires the highest possible credibility with the students. Be sure to introduce yourself thoroughly, stating your background, mountain travel experience, personal involvement with avalanches, professional associations, and other pertinent information.

Through the course your credibility will be enhanced or undermined by your own actions. Professionalism is required. Consistency in technique, ensuring that your actions demonstrate what you say, consistent use of safety measures, a positive attitude towards an adequate safety margin, and a demonstrated respect for potentially life threatening avalanche involvements are key factors in maintaining and building your credibility as an instructor. THE STUDENTS ARE ALL WATCHING YOU AND LEARNING FROM YOUR WORDS, ACTIONS AND ATTITUDES. <u>DEMONSTRATE PROFESSIONALISM</u>.

Do not be reluctant to explain your uncertainties. Avalanche phenomenon are not totally understood. There are no absolutes; rather many complex and diverse variables which act in combination to produce avalanches.

KNOWLEDGE, EXPERIENCE AND THOUGHTFUL ANALYSIS ARE NECESSARY TO AVOID AVALANCHE ACCIDENTS. Stress this fact to your students.

Relate your uncertainties to the group when required, and then demonstrate a wide margin of safety to compensate for the information gaps identified.

B. PROPOSED SCHEDULE

DAY 1

Classroom: 1. Introduction to course
2. Avalanche phenomenon
3. Snowpack development

LUNCH

Outdoors: 4. Weather and snowpack observations
5. Weather observation and record data
6. Snowpack structure demonstrate test profile recording data

DINNER

Classroom: 7. Discussion of weather test profile data, demonstrate and have students plot test profile
8. Movie: "Avalanche"

DAY 2

Classroom: 1. Avalanche terrain
2. Safety measures
3. Travel to site of field trip

LUNCH

Outdoors: 4. Student practice of safety measures, pieps safe travel practices in avalanche terrain.
5. Observation and evaluation of avalanche terrain

DINNER

Classroom: Stability evaluation

DAY 3

Outdoors: 1. Students observe, practice stability evaluation technique and tests. (Test profile, weather influences, block test, pie test, Swiss wedge, compressive test).

LUNCH

Outdoors: 2. Route selection, practice safety measures. Demonstrate test skiing.
3. Forecasting hazard for route on different aspect and higher/lower elevation.

DINNER

Classroom: 4. Search and rescue case histories of local accidents.

DAY 4

Outdoors: 1. Leadership skills, practice all preceeding topics with students practicing leadership under supervision.

LUNCH

Outdoors: 2. Avalanche rescue practice, with emphasis on leadership development.

DINNER

Classroom: 3. Recap of day, discussion of leadership, group critique of rescue practice.
4. Student evaluations of course and instructors.

Note: This schedule is for example only. Course location or weather variables may necessitate modification for maximum participant benefit.

INTRODUCTION TO COURSE

INTRODUCTION TO COURSE

0.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparancies
- slide projector
- carousel and slides
- flip chart, pens and paper
- form for participant sign in
- form for participant equipment loan
- participant equipment for handout

C. Suggested time - 1/2 hour

0.1 WELCOME

0.1.1 Introduce instructors and their backgrounds, why they are qualified to teach this course.

0.1.2 Have students introduce themselves; state why they are here, what they want to learn; have they been involved in an avalanche, what happened and why?

0.2 MOTIVATION

Leader's of groups of backcountry travellers are responsible for knowledgeable and rational decision making. Understanding of the avalanche phenomena, the ability to evaluate snowpack stability and conduct proper avoidance and emergency responses is an integral part of leadership in winter travel.

0.3 VALIDATION

0.3.1 Avalanche Accidents in Canada, Volumes 1 and 2 NRCC publications #17292 and #18525.

0.3.2 Case histories of good leadership from your experience, case histories of inadequate leadership from your experience or Avalanche Accidents in Canada. USE SLIDES IF AVAILABLE.

0.4 COURSE OUTLINE

0.4.1 Handout zerox copy of proposed schedule, short discussion of course format - 16 hours classroom, 24 hours field time. Note that format may be flexible for weather or other reasons.

0.4.2 This course is designed for group leaders and assumes some previous knowledge of the subject matter.

0.4.3 Handout of equipment for participants, have them sign sheet for all materials received.

0.4.4 Draw attention to personal equipment, trip preparation, transportation, meals, classroom rules, punctuality, safety considerations on field trips, protective clothing requirements, etc.

0.5 COURSE OBJECTIVES

(Relate each one to appropriate class or field session, as per outline).

At the end of this session the participant should be able to:

1. Describe the avalanche phenomena and their consequences
2. Describe the process which determine how and why changes occur in the snowpack, and explain how climate influences this snowpack development
3. Make and record meaningful weather and snow pack observations
4. Interpret weather and snowpack observations as an aid to decision making
5. Recognize avalanche prone and avalanche safe terrain, and be able to describe how terrain variables influence the process of evaluating avalanche terrain
6. List and demonstrate the use of equipment required for travel in avalanche terrain
7. Describe safe travel techniques and list mitigating actions if caught or buried in an avalanche
8. State criteria for evaluating snowpack stability and describe how changes in snowpack structure or weather influence snowpack stability
9. Conduct backcountry avalanche rescue operations
10. Demonstrate group control and avalanche hazard mitigating techniques condusive to good group leadership.

**Ensure that each participants reasons for attending this course are met in the above discussion of course objectives.

0.5.2 SUMMARY

*STRESS THAT WINTER TRAVEL IS A PLEASURABLE AND REWARDING EXPERIENCE. THE MARGIN OF SAFETY DEPENDS OF KNOWLEDGEABLE AND RATIONAL LEADERSHIP. THE GOAL OF THIS COURSE IS TO ASSIST IN THE DEVELOPMENT OF GOOD LEADERS.

0.5.3 LINK

The first topic is avalanche phenomenon, the various types of avalanches and their effects.

CHAPTER I

UNDERSTANDING AVALANCHE PHENOMENON

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UNDERSTANDING AVALANCHE PHENOMENON

1.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids
- overhead projector
- O.H. transparencies
- slide projector
- carousel
- slides
- screen(s)
- 16 mm projector
- film - "Avalanche Dynamics"
- flip chart, paper and pens

C. Suggested Time - 1 1/2 hours

1.1 AIM

Understanding of the appearance, formation, release, size and flow characteristics, and effects of the various types of avalanches.

1.2 OBJECTIVES

At the end of the session the course participant should be able to:

1. Describe avalanche formation
2. Describe avalanche types and their effects
3. Describe avalanche motion and flow characteristics
4. State avalanche nomenclature
5. State avalanche size classification.

1.3 MOTIVATION

The type and size of the avalanche determines its destructive potential. Avalanche phenomenon must be understood before the student can make valid safety decisions. (Bring in case histories, anecdotes of students involvements, etc.)

**NOTE: That at present the physical sciences do not totally explain avalanche release mechanisms, and many concepts are popular but not proven. Reality is more important than theory for the winter traveller.

1.4 VALIDATION

1. Avalanches - Protection, Location, Rescue
   Vanni Eigenmann Foundation
   Chapter 1, pp. 9 - 16

2. Avalanche Handbook
   USDA - FS #489
   Chapter 4, pp. 65 - 90

3. Film - "Avalanche Dynamics"

1.5 AVALANCHE PHENOMENON

1.5.1 Definition: AVALANCHE - A mass of snow that sometimes contains other material, moving rapidly downslope.

1.5.2 The Canadian Avalanche Size Classification System (O.H. #2). Explain and relate to avalanche slides that follow.

1.5.3 Loose Snow Avalanche (Slide #1)

- starts at a point in cohesionless snow
- entrains more mass as it moves downslope
- occurs where slope steepness exceeds the natural angle of repose of the snow
- release is progressive, no fracture line, indistinct bed surface
- may be wet or dry, loose with little internal cohesion
- size dependent on snow and terrain characteristics.

1.5.3.1 Dry, Loose Avalanche (Slide #2)

- mostly during storms
- new snowfall, little wind at that location
- occurs as snow crystal branches sublimate, before sintering
- indicates stabilization of steep upper slopes
- may load or trigger slabs on lower slopes
- destructive potential dependant on moisture, mass, speed and terrain (illustrate with case histories)
- may be triggered by any disturbance of the snow surface
- describe flow characteristics (slides as available to instructor or "Avalanche Dynamics" film
- small sizes may pose little hazard to winter travellers.

1.5.3.2 Wet, Loose Avalanche (Slide #2)

-slushy new or old snow
-loss of cohesion caused by warm weather
-may involve surface only, or full depth in spring
-may be lubricated by rain or melt water
-rock outcrops on sun exposed slopes usually first indicators
-triggered by any disturbance on the snow surface when temperatures are above freezing and the snow is isothermal at 0°C
-describe flow characteristics
-destructive potential dependant on moisture, mass, speed and terrain; more dangerous to buried victim due to lack of air in pore spaces.

1.5.4 Slab Avlanche (Slide #4)

-most significant source of winter hazard in the mountains
*STRESS -caused by layering in the snowpack, relatively strong over relatively weak layers of poor bonding between layers
-nomenclature - crown, flanks, stauchwall, bed surface (Slide #5)
-entire slab fails at once (Slide #6)
-may entrain more mass as it moves downhill
-may involve surface layers or the entire snowpack (Slide #6 and #7)
-may range in size from Class I to Class V (use quiz as reviewed).

1.5.4.1 Hard Slabs (Slide #10)

-usually found at high elevations and above treeline where high winds prevail
-snow is very tough and brittle; dull, chalky appearance
-hard slabs may feel hollow underfoot as they bridge weaker layers below
-may involve the entire snowpack
-surface may be so hard that edging skis is difficult
-may form at very low temperatures
-unpredictable, may support numerous skiers before releasing
-may propogate over large areas, entire mountainsides
-deposits may be moist or dry, contains large blocks (Slide #11)
-pose serious threat to victim caught.

1.5.4.2 <u>Soft Slabs</u> (Slide *12)

- -usually new snowfall with light winds, <u>surface layers only</u>
- -usually formed by intense precipitation and high humidity
- -easily released by skiing, though not necessarily by the first skier
- -internal cohesion causes ski tracks to be "sharp" in profile
- -fractures where tensile stresses are high
- -slab quickly disintegrates, deposit is dry and powdery (Slide *13)
- -duration of hazard dependent on new snow crystal types, temperature/metamorphism variables
- -hazard to victim caught is dependent on size and burial depth.

1.5.5 <u>AVALANCHE MOTION</u>

- -nomenclature - starting zone, track, runout zone (O.H. *4)
- -describe - gliding motion (Slide *14)
- -turbulent flow (Slide *15)
- -mixed turbulent (Slide *16)
- -powder avalanche (Slide *17)
- -dry/wet (Slide *18)
- -speeds dependent on topography and incline
- -speed greatest in centre, slower at edges
- -more hazard in gullies than unconfined slopes
- -faster speeds generate long runout distances.

1.5.6 <u>FILM</u>: "Avalanche Dynamics" - 16 mm

1.5.7 <u>SUMMARY</u>

Wrap up using key words.

1.5.8 <u>LINK</u>

Next topic is "SNOWPACK DEVELOPMENT" which will describe snow and how it changes over time.

These changes determine snowpack stability and avalanche activity.

Understanding snowpack development allows us to make better avalanche safety decisions.

TABLE I

THE CANADIAN AVALANCHE SIZE CLASSIFICATION SYSTEM

Classify the avalanches by estimating their destructive effect from the deposited snow. For this, picture the persons, cars, building, or trees in locations where they would receive the greatest damage; i.e. in the track or the beginning of the runout zone.

The following numerical must be applied, and half sizes, 1.5, 2.5, 3.5, 4.5 may be used:

0 No avalanche - explosives were applied, or the slope was tested by skiing, but no avalanche was released.

1 Sluff - the avalanche was too small to injure a person

2 The avalanche could bury a person.

3 The avalanche could bury a car, destroy a small building, or break a few trees.

4 The avalanche could destroy a railway car, large truck, several buildings, or a forest with an area up to four hectares (ten acres).

5 The avalanche could destroy a village or forest areas of 40 hectares (100 acres).

CHAPTER II

SNOWPACK DEVELOPMENT

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SNOWPACK DEVELOPMENT

2.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- slide projector
- carousel
- slides
- flip chart, paper and pens
- handout - I.C.S.

C. Suggested time - 2 hours

2.1 AIM

Understanding of the rounding, sintering, faceting and depth hoar formation process; and how and why these processes effect snowpack stability.

2.2 OBJECTIVES

At the end of this session the participant should be able to:

1. Describe the rounding and sintering process
2. Explain the effects of these processes on new snow
3. Describe the processes of faceting, formation of depth hoar, and formation of surface hoar
4. Explain the effects of depth hoar and surface hoar
5. Describe the melt-freeze process
6. Explain the effects of the melt-freeze cycle
7. Explain how climatic influences effect snowpack development.

2.3 MOTIVATION

An understanding of how snow changes under the influences of temperature, disturbance and time, is crucial to determine snowpack stability, hazard forecasting, and valid decision making in mountian travel.

A thorough understanding of snowpack development is required before the test profile can be interpreted and the results projected for the planned route of travel.

2.4 VALIDATION

1. Avalanche Handbook
   USDA - FS #489
   Chapter 3, pp. 40 - 62

2. Avalanche Safety for Skiers and Climbers
   Tony Daffern
   Chapter 3, pp. 43 - 67

3. Guidelines for Weather, Snowpack and Avalanche Observations
   N.R.C. Tech. Mem. #132
   pp. 23 - 26

4. Film - "Snow Metamorphism"

2.5 SNOWPACK DEVELOPMENT

2.5.1 The Formation of Snow

-water vapour super-cooled by uplift (convection, frontal uplifting or terrain)
-capacity of air to hold water vapour decreases with cooling temperatures
-tiny droplets condense onto nuclei (dirt, salt etc.)
-upon contact with nuclei super-cooled water freezes into ice particles. These particles grow by SUBLIMATION - THE TRANSITION FROM GAS TO SOLID OR VICE VERSA, WITHOUT PASSING THROUGH A LIQUID STATE.
**Ensure students understand this process. Essential for understanding snowpack processes. Use example of dry ice "melting".

-particles brought to ground by gravity as snow. Usually a six sided crystal (dependent on water vapour concentrations and temperatures)
-snow reaching the ground may range from perfect crystals to tiny fragments, (wind influences), often a combination of both.

2.5.2 Types of New Snow

-give handout from "International Classification of Snow"
-briefly outline characteristics of each crystal type as they relate to stability of new and settled snow.

LEAD IN - snow is changing, moving constantly. THERE ARE TWO COMPETING PROCESSES. Rounding up and sintering which promote strengthening , and faceting and hoar formation which promote weakening of the snowpack.

2.6 SNOW METAMORPHISM

2.6.1 Rounding and Sintering

**Stress this is a perfect, theorectical situation, without consideration of physical disturbance, weight or warming temperatures.

Note: Stress to students that this rounding and sintering process occurs quickly at "warm" (0° to -5°) temperatures, and almost stops at -20° and colder. Pressure (i.e. deep snow weight) and physical disturbance (skis, wind, etc.) will accelerate these processes.

2.6.1.1 New Snow + = N.S. Symbol (Slide #1)

-initial stability of new snow due to inter-locking of crystal "arms" (i.e. new snow hanging from roof, cornice, etc.)
-initial specific gravity from .04 to .15 normally (85% to 96% air, relate to snow as structural material
-sublimation of mass from arms to centre of crystals due to high and low vapour pressure differences
-this causes settlement as crystals become smaller.

2.6.1.2 Rounding (Partially settled snow) ⋀ = P.S. Symbol (Slide #2)

Note: this is a critical period for new snow instability as the interlocking of crystal arms break down. May result in "direct action" avalanches.

-initial loosening of interlocking arms
-original crystal form disappearing
-specific gravity normally from .15 to .20 (80 to 85%) air, structural material stronger)
-snow is "settling" and getting stronger as crystal sizes decrease (shorter levers) and and sinter to each other
-sublimation of mass to centre of crystal continues.

2.6.1.3 <u>Sintering</u> • = Rounds Symbol
(Slide #3)

-original crystal form indistinguishable, known as "round"
-mass from arms has sublimated to crystal centre
-sintering occurs between crystals caused by vapour phase transport
-specific gravity normally .20 to .60 (40% to 80% air, structure material stronger yet)
-snow has settled and become strong as small crystals (short levers) <u>sinter</u> together.

**Stress that except for the initial period of new snow instability caused by loss of inter-locking crystal arms, rounding and sintering is a stabilizing influence that normally strengthens the snowpack.

2.6.2 <u>FACETING AND HOAR FORMATION</u>

Faceting and hoar formation requires:

-ground temperature at or near 0°C (O.H.#1)
-relatively shallow, porous snowpack (O.H. #2) significant and insignificant temperature gradients)
-temperature gradient, 1°C/10 CM H.S.

2.6.2.1 <u>Faceting</u> □ = Facet Symbol (Slide #4)

-lower layers relatively warm generate water molecular activity
-frozen water molecule sublimates to vapour, vapour flows to colder temperature crystals higher in the snowpack
-vapour re-freezes on cold crystal causing growth in crystal size but not in crystal neck size (levers grow longer)
-loss of mass from lower layer results, <u>causing structural weakening of the snowpack</u>.

2.6.2.2 <u>Formation of Depth Hoar</u>
Λ = D.H. Symbol (Slide #5)

-faceting process continues, grains grow very large (5 to 10 mm) with fragile necks (very long levers)
-grains are striated or cup shaped with angular corners and distinct faces

-few contact points result in poor sintering
-mass is being transported upward in the snow-pack, result decrease in density, result decrease in strength
-depth hoar layer growth slowed by ice crusts, dense layers, etc. that inhibits flow of water vapour
-depth hoar often forms around rocks and trees due to heat transfer from ground and density decrease
-depth hoar extremely fragile and therefore dangerous for deep slab instability.

2.6.2.3 Formation of Surface Hoar
V = S.H. Symbol (Slide #6)

-daytime air mass is warm, holds substantial water vapour
-cold clear nights, air temperature drops, air becomes super saturated
-water vapour sublimates from air to cold snow surface as frozen dew
-surface hoar crystals grow from surface upwards, getting larger with height
-surface hoar forms extremely unstable layers in the snowpack
-surface hoar crystals do not break down (undergo rounding and sintering and strengthen quickly), these layers can remain unstable for months.

Surface hoar formation requires:

1. warm, moist daytime airmass
2. lack of wind
3. cold, clear nights
4. cold snow surface
   (O.H. #2 - requirements for surface hoar formation).

2.6.3. Melt/Freeze Metamorphism

Melt Freeze ○ = M.F. Symbol (Slide #7)

-grains start to melt, surface tension binds the free water to the melting grains
-small grains melt first, lose their mass to the large grains
-sintering breaks down, resulting in large, wet, loose snow grains like ball bearings, very weak
-cause of isothermal, wet snow avalanches

-while frozen, MF grains are very strong due to the large necks formed by free water during the melt cycle.

**Stress to the class that, depending on climatic influences, two of these processes (rounding and sintering/faceting and formation of depth hoar, or rounding and sintering, melt freeze) are often competing within the snowpack.

2.7 CLIMATIC VARIATIONS

2.7.1 Rockies

In the rockies two physical processes, rounding sintering and faceting/formation of depth hoar are usually competing in winter. The relatively shallow snowpack and cold temperatures make faceted or depth hoar layers the usual structure near the bottom of the pack. Rounded and sintered layers are common in the top layers of the pack. Most rocky mountain avalanches fail on a faceted or depth hoar layer, with new snow acting as an overloading agent to trigger the release. The rocky mountain snowpack is inherently unstable most winters. ELABORATE from your experience.

2.7.2 Interior Ranges

The interior ranges usually experience heavier snowfalls and more moderated temperatures. Rounding and sintering processes are usually dominant. Facets or depth hoar is usually only a critical factor in the early season and on wind scoured slopes where the snowpack is shallow. Most avalanches in the interior ranges release in unstable layers of new snow, MF crusts or on buried surface hoar layers. ELABORATE from your experience.

2.7.3 Coast Mountains

The coast mountains usually receive heavy snowfalls and mild temperatures. In the coast ranges, rounding and sintering and melt-freeze processes are dominant. Faceted and depth hoar layers occassionally form in the shallow early seasons snowpack when extreme cold temperatures occur. Surface hoar may form in mid-winter. Critical weak layers are commonly - weak new snow crystals; poorly bonding layers of crusts; or wet layers caused by meltwater lubrication. ELABORATE from your experience.

2.8 Sketch out Typical Snowpack Stratification for Your Area In:

1. early winter
2. mid-winter
3. spring

2.9 Summary

Wrap up using key words: sublimation, new snow, rounding, sintering, faceting, formation of depth hoar, formation of surface hoar, melt-freeze, climatic influence.

2.10 Link

Next topic is weather observations and standardized data recording.

Weather is the modifier that determines the type and rate of change in the snowpack.

Observation and understanding of weather influences, combined with an understanding of snow physics will aid you in making valid snowpack stability forecasts.

CHAPTER III

WEATHER OBSERVATIONS AND RECORDING DATA

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3.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- flip chart, paper and pens
- handout
- field book

C. Suggested time - 1 1/2 hours

3.1 AIM

Understanding of the meaningful weather and snowpack observations that are easily taken with minimal equipment by the mountain traveller, and how to record these observations.

3.2 OBJECTIVES

At the end of this session the course participant should be able to:

1. Make and record accurate and meaningful weather observations
2. Record weather observations per N.R.C. guidelines
3. Describe the procedure for test snow profiles.

3.3 MOTIVATION

Weather is the modifier that determines the type and rate of change in the snowpack, determining snowpack stability. Understanding snowpack stability is essential to safe winter travel.

Leaders of groups are legally and morally responsible for the safety of their companions. Weather observations properly taken and recorded, assist the group leader in making valid safety decisions. Accurate records of these observations assist the leader in proving the case for the "reasonable man" in case of accident.

Test profiles are an easy and valuable check on the snowpack, and allows the winter traveller to determine special variations in the mountain snowpack.

3.4 VALIDATION

1. Guidelines for Weather, Snowpack and Avalanche Observations
NRC Tech. Mem. #132

2. Professional mountain guides observe and record weather in this manner.

3.5 WEATHER INFLUENCES - link back to "Snow Physics" chapter

3.5.1 Weather from first snowfall through last snow melt, determines snowpack stability.

3.5.2 The snowpack as seen in a test profile is a calendar of the winter's weather, modified by snow physics.

3.5.3 Have students evaluate WX influences on the season to date.

3.6 WEATHER OBSERVATIONS

NOTE: If possible, observation sites should be relatively level, subject to minimum drifting and the distance from obstructions (trees, etc.) should be about equal to the height of the obstructions.

3.6.1 Weather Data

Weather observations useful to the backcountry traveller are:

-sky condition
-precipitation and rate
-temperature
-height of new snow (H.N.)
-total snow depth (H.S.)
-surface penetrability (PENT.)
-wind at base
-wind at mountain top
-comments

EXPLAIN WHY EACH IS SIGNIFICANT

3.7 WEATHER DATA RECORDING

At the top of the field book page, record the location and elevation of the study plot, as well as the year.

Carry out and record the observations in the following sequence:

A. Date - record month and date
B. Time - record the time of observation to the closest five minutes on the 24 hour scale (5:10 pm is 17:10)
C. Sky condition - classify the amount of cloud cover and record it with one of the symbols below.

CLASS	SYMBOL	DESCRIPTION
Clear		No clouds
Partly cloudy		Scatter clouds; sky is half or less covered with clouds
Cloudy		Broken clouds; more than half but not all of the sky is covered with clouds
Overcast		Sky is completely covered
Obscured		Cloud elements are not discernible; for example, the observer is in fog, smoke, haze

Add the letter "H" to the symbol when the sky is covered with haze rather than clouds.

3.7.1 Precipitation Rate

Note the type and rate of precipitation at the time of observation. Record the rate of snowfall in centimeters of snow accumulation per hour.

SYMBOL		DESCRIPTION
NIL		No precipitation
*-1	*-	Continuous snowfall that accumulates at a rate of less than 1 cm per hour
*1		Snow accumulates at a rate of about 1 cm per hour
*2		Snow accumulates at a rate of about 2 cm per hour
*3		Snow accumulates at a rate of about 3 cm per hour
VLR		Very light rain
LR		Light rain; accumulation of 3mm of water per hour or less
MR		Moderate rain; accumulations of 3-8 mm of water per hour
HR		Heavy rain; accumulation of 8 mm of water per hour or more.

3.7.2 Air Temperature

Hold thermometer ±1 meter above snow surface, swing dry thermometer for one minute, and read to the nearest degree Celcius.

3.7.3 Height of New Snow

Measure new snowfall with a ruler. Record the measurement to the nearest centimeter.

3.7.4 Height of Snowpack

With ruler or probe measure the total depth of the snowpack on the ground. Take several soundings and record the average depth.

3.7.5 Foot Penetration

Step into undisturbed snow and gently put the full body weight on one foot. Measure the depth of the footprint (in centimetres).

Comment:

The footprint depths vary between observers, but experience has shown that the variations usually are insignificant for avalanche hazard forecasting.

3.7.7 Wind

Record the wind speed and direction in the vicinity of the observation plot. When visibility allows, observe and record the direction and speed at high elevation near the avalanche starting zones.

Note the direction from which the wind blows with respect to the eight points of the compass: N, NE, E, SE, S, SW, W, NW.

Classify the wind speed by observing the motion of trees, flags, snow.

CLASS	SPEED		DESCRIPTION
	km/h	m/s	
Calm	0	0	No air motion; smoke rises vertically
Light	0-25	0-7	Light to gentle breeze; flags and twigs in motion
Moderate	26-40	8-11	Fresh breeze; small trees sway; flags stretched; snow begins to drift
Strong	greater than 40 or greater than 11		Strong breeze and gale; whole trees in motion; snow drifting

Comment The description of the effects of wind speed are rules of thumb. Observers should develop a feeling for wind speed.

3.7.8 Other Observations

Record other useful information as applicable. Keep notes concise and accurate.

3.7.9 Sample Weather Observations
See Table 2 (O.H. *2)

- have students prepare their field book as illustrated on O.H. *2
- explain that after class proper techniques for taking observations will be demonstrated outside.

3.8 SNOW PROFILES

*A field examination of Snowpack Development:

3.8.1 Purpose

Test snow profiles are an abbreviated form of snow profiles, containing only the information that is most significant for snow stability - the presence and characteristics of weak layers, and the snow temperatures. The objective of test profiles is to study and record the variation of the snow with exposure and elevation and to correlate the conditions with those observed on the standard study plot.

The pit for a test profile needs to be excavated only as deep as weak layers exist or as temperatures are significant. The approximate depth required should be known from continuous monitoring of snowpack development during the winter, and from full profiles.

3.8.2 Location

Test profiles must be indicative of the snow conditions on avalanche slopes. When selecting a site, keep in mind that exposure to wind, exposure to sun, and elevation are the factors that have the strongest influence on the variations of the snowpack in space. The test profile location should meet the following criteria:

- at least one meter from the tips of tree branches
- not in a water hole
- not contain avalanche debris

3.8.3 Equipment

The following equipment is needed for observation of test snow profiles:

- snow shovel
- snow thermometer
- ruler, graduated in centimeters
- magnifying glass
- crystal screen
- notebook of water-resistant paper
- two pencils
- gloves

The following equipment is optional but recommended:

-collapsible probe
-saw

3.8.4 Procedure

3.8.4.1 With the probe or ski pole, determine roughly the location of weak layers, the depth necessary for the pit, and the total snow depth.

3.8.4.2 Record date, time, names of observers, location, elevation, aspect, inclination of terrain, sky cover, precipitation and wind.

3.8.4.3 Observe the air temperature in the shade about 1.5 m above the snow surface.

3.8.4.4 Observe the surface roughness; measure the surface penetration.

3.8.4.5 Dig the pit at least as deep as instabilities are suspected. Cut a smooth face on the shady side for identification of layers.

3.8.4.6 Measure the snow temperatures as necessary.

3.8.4.7 Determine the location of significant layers and record their height. When the pit is not excavated to the ground, record the location of the layers by measuring from the surface down and make a note of the total snow depth determined by probing.

3.8.4.8 Observe the hardness, crystal shape, and free water content of significant layers.

3.8.4.9 Make two shovel shear tests near weak layers.

3.8.4.10 Comment on the stability of the snow observed in the profile.

3.8.4.11 Add other observations that are relevant to snow stability, such as drifts, settling snow, sluffing, results of ski tests.

3.9 SUMMARY

Wrap up using key words.

3.10 LINK

Weather influences and snowpack structure are the basis for stability evaluation.

After lunch, dress for outdoors for full afternoon; bring all gear.

Class will do weather observations and record the data.

Following the weather we will look at existing snow pack structure and demonstrate a test profile.

TABLE 2

SAMPLE WEATHER OBSERVATIONS

SNOW AND WEATHER OBSERVATIONS - BACKCOUNTRY				
LOCATION	Peyto Hut	Bow Hut	Balfour Hut	408067 Niles Glacier
ELEVATION	8200'	8300'	8300'	8700'
ASPECT	S.W.	N.E.	S	Flat
OBSERVER	J.B.	T.B.	J.B.	J.B.
DATE	01-29	01-30	01-31	02-01
TIME	07:40	09:00	08:15	07:25
SKY	⊕	⊕	⦶	○
PRECIP. INT.	*-1	*1	*-1	NIL
TEMP °C	-17	-6	-3	-11
NEW SNOW	2	13	9	4
SNOWPACK	110	150	140	155
FOOT PENT.	5	15	26	25
WIND BASE	Calm	SW-L	SW-M	W-L
WIND HIGH	SW-L	SW-M	W-M	NW-M
OTHER OBSERVATIONS	Fluff on wind crust	Good dry powder Snow started @ 19:00 hrs. 01-29	2 cm wind crust Estimate 10 cm H.N. yesterday	Avalanche down on NE face Mt Ogden start @ 8500'

TABLE 2A - SAMPLE FIELD BOOK PAGE FOR TEST SNOW PROFILE

TEST PROFILE	OBSERVER: N. SMITH
DATE: 1980-02-06 TIME 1045	

LOCATION: SKIERS DELIGHT	ASPECT:	N E	INCLINE	25°
ELEVATION: 1750 m	SKY:	⦶	PRECIP: NIL	WIND: N. MOD
SURFACE ROUGHNESS: RANDOM FURROWS	FOOT PENETR.	38 cm	SKI PENETR:	4 cm

H cm	R	F	D mm	W	SHOVEL	COMMENT	H cm	T
0 =	SURFACE						AIR	-12°C
	FIST						10	-14
6						WEAK BOND BETWEEN CRUST AND	30	-11
	CRUST					SNOW ABOVE CRUST	64	-8
8								
	4 F	∧		DRY				
63								
	–	V	2-3		MOD	SOME ROUNDING OF CRYSTALS		
64								
	1 F	□ ●		DRY				
97								

TOTAL DEPTH 183 cm

SNOW IS STABLE IN PIT AND ON N-EXPOSURES

DRIFTS BEHIND TREES FROM N-WIND;

WIND HAS REMOVED SNOW FROM TREES.

CHAPTER IV

PM - DAY I FIELD TRIP

CHAPTER IV

PM - DAY I FIELD TRIP

4.0 INSTRUCTOR'S NOTES

A. Location - outdoors at suitable site nearby

B. Instructional aids - shovel
- snow saw
- probe
- 8X hand lens
- crystal screen
- hand thermometer
- notebook
- pencils
- metric folding ruler

C. Suggested time - 3 hours

4.1 AIM

To have course participants observe, practice and record snow and weather observations.

4.2 OBJECTIVES

At the end of this session, the course participant should be able to:

1. Demonstrate proper techniques for observing weather
2. Demonstrate proper techniques for recording weather observations
3. Demonstrate test snow profile procedures
4. Identify significant layers in the snowpack
5. Describe how proceeding weather and snow physics determines layering characteristics of the snowpack.

4.3 MOTIVATION

Proper technique is required to accurately observe weather and snowpack parameters. These measured parameters will aid the observer in forecasting the changes in the snowpack structure that will influence the snowpack stability.

Professional avalanche control operators spend significant time and money to determine weather and snowpack conditions, as they are the key to understanding snowpack stability trends. As the backcountry traveller is responsible for the safety of themselves and their group, he or she too must understand these key parameters.

4.4 VALIDATION

1. Recount a short, personal anecdote where weather and snowpack observations prevented a potentially hazardous situation.

2. Guidelines for Weather, Snowpack and Avalanche Observations
   N.R.C. Tech. Mem. #132.

4.5 WEATHER OBSERVATIONS

4.5.1 Demonstrate proper techniques for observing and recording weather as per NRC guidelines.

4.5.2 Act as quality control, discuss and check students observations.

4.5.3 Explain estimating "rule of thumb", how to determine new/old snow interface, etc.

4.6 SNOWPACK STRUCTURE

4.6.1 Demonstrate test profile procedures per NRC guidelines.

4.6.2 Demonstrate shovel shear test per NRC guidelines (see following text).

4.6.3 Have students record observations in their field books, in the proper format.

4.6.4 Discuss layering, significant failure planes, ET, TG, MF layers, and relate these to preceding weather. LINK BACK TO SNOW PHYSICS LECTURE.

4.6.5 Relate test profile results to snowpack structure on adjacent slopes at higher elevations, more wind, other aspects, etc.

4.7 SUMMARY

Wrap up using key words and concepts.

4.8 LINK

After dinner, class will meet and plot test profile, discuss snowpack structure and prepare for tomorrows field trip.

SHOVEL SHEAR TEST

A. Application

The shovel shear test supplements snow profile observations by yielding information about the location where the snow could fail in shear and the range of effort required to produce a failure.

The test is best applied for identification of deep unstable layers. It does not always produce useful results in layers close to the snow surface. Such layers, usually containing new snow, are better tested with the tilt board and shear frame (see chapter "Shear Frame Test").

When applying the test to an inclined snowpack, it must be kept in mind that snow on an incline fails with less external effort than the same snow on level ground. Observers are cautioned also that the test indicates only possible shear failure, but does not produce information about the strength of a slab above a shear plane.

B. Equipment

The equipment required is that listed for test snow profiles.

C. Procedure

1. Expose a fresh pit wall by cutting back about 0.2 m from the pit face.

2. Excavate a chimney about 0.2 m wide and 0.4 m deep (see figure 1).

3. Mark a square block with sides 0.3 m to 0.35 at the side of the chimney.

4. Make a triangular or rectangular cut at the other side of the block.

5. Make a vertical cut at the back of the block to a depth about 0.2 m below the level of suspected shear failure planes.

6. Carefully insert the shovel at the back of the block.

7. Pull gently on the shovel handle.

8. Record the effort necessary to break the snow by:

very easy	fails during cutting or insertion of the shovel
easy	fails with minimum pressure
moderate	fails with moderate pressure
hard	fails with firm sustained pressure
collapse	block settles when cut

9. Measure the location of fracture plane from the snow surface.

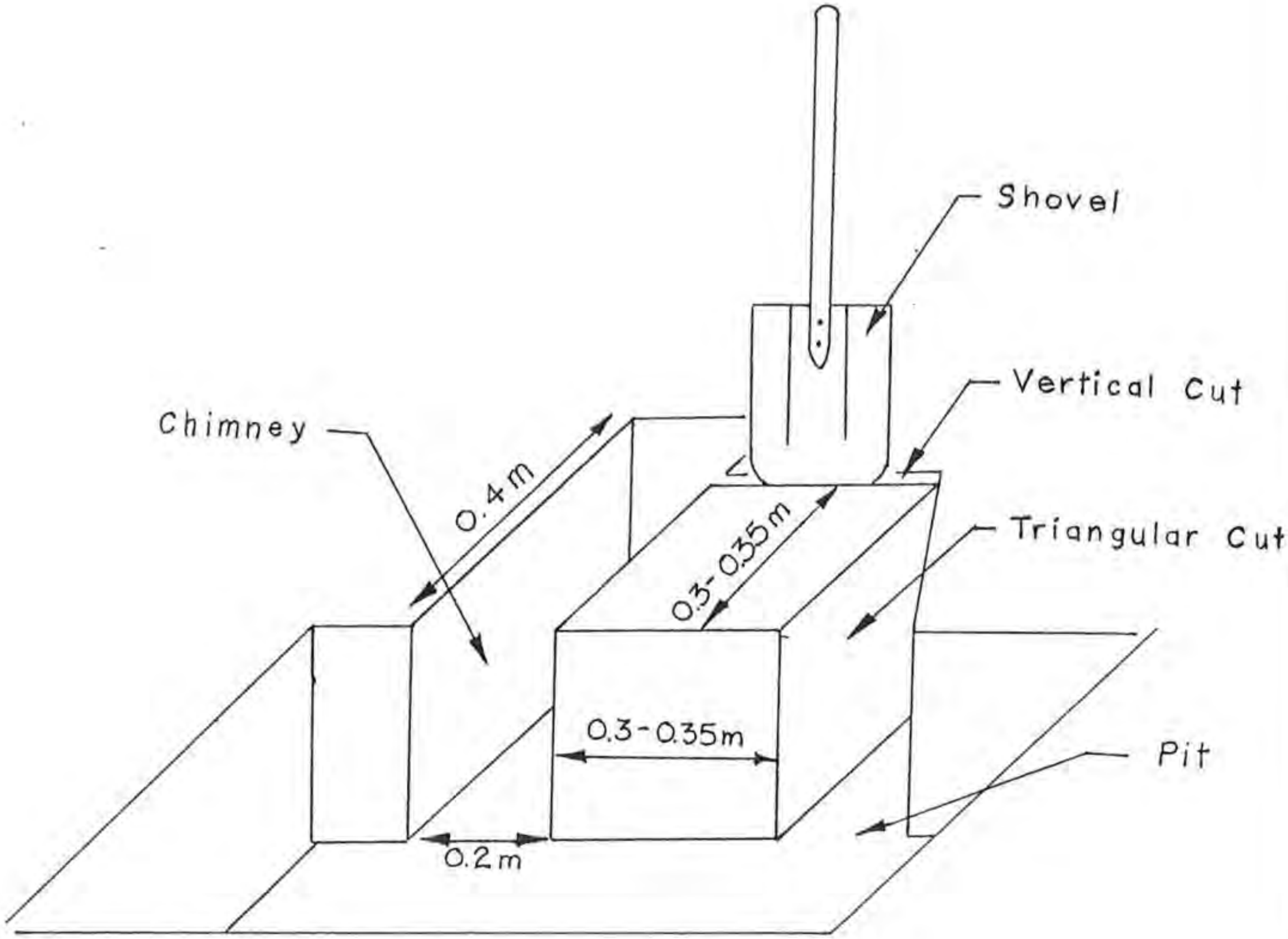
10. Turn the block upside down and check the type of fracture. The test is valid only when the block has failed in a smooth shear plane.

11. Record in the snow profile notes the location of the fracture plane and the effort.

12. Inspect the type of snow crystals in the shear plane.

Comment: The block is best cut with a saw, but also a ski may be used for that purpose.

SHOVEL SHEAR TEST



EVENING - DAY 1

A. Weather Observations

Review weather observations, discuss weather forecasts, where to obtain them, etc. Involve students in discussion.

B. Test Profile

1. Demonstrate methods for plotting test profile.

2. Explain symbols for profiles.

3. Review present snowpack structure, relate observations of test profile to past weather and snow physics.

CHAPTER V

AVALANCHE TERRAIN

CHAPTER V

AVALANCHE TERRAIN

5.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- slide projector
- carousel and slides
- flip chart and pens
- extension cords

C. Suggested time - 1 1/2 hours

5.1 AIM

Understanding of the key factors of slope, smoothness and shape that determine safe and unsafe travel routes.

5.2 OBJECTIVES

At the end of this session the participant should be able to:

1. Recognize typical avalanche paths
2. Recognize what is safe terrain (to develop route-finding skills) and what is dangerous terrain (to practice avoidance)
3. State the effects of slope incline, aspect elevation, configuration and anchorage on the formation of avalanches
4. A thought process for evaluating avalanche terrain.

5.3 MOTIVATION

Winter travellers must be able to recognize avalanche terrain before valid safety decisions are possible. When the snowpack is unstable travel is still safe as long as ALL potential terrain is avoided.

5.4 VALIDATION

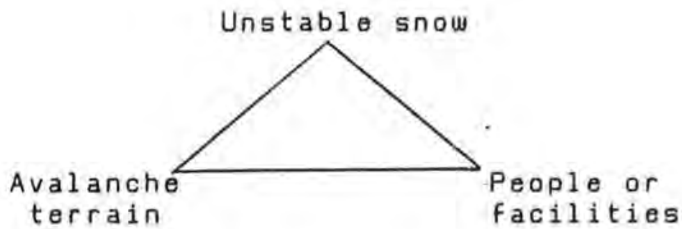
1. From your experience or knowledge, relate a short antidote on an avalanche accident caused by failure to recognize avalanche terrain (eg. Stanley Glacier, 1979).

2. Avalanche Accidents in Canada, Volume 1 and 2, N.R.C. #17292 and #18525

3. Avalanche Handbook
   USDA - FS #489
   Chapter 4, pp. 76 - 90

5.5 AVALANCHE TERRAIN

5.5.1 The Avalanche Accident Triangle



STRESS THIS CONCEPT! EXPLAIN HOW "REMOVING" ANY ONE OF THESE FACTORS WILL MAKE AN AVALANCHE ACCIDENT IMPOSSIBLE.

5.5.2 Definitions

1. Define avlanche path and how it is subdivided (O.H. #1)
2. Discuss terrain - chute type (Slide #1)
   - open slope (Slide #2)
   - multiple starting zone (Slide #3).

5.5.3 Starting Zone

(a) Incline

Discuss the signifance of slope angles; safe or unsafe; what is steep, difference in critical angles for wet and dry snow. MOST IMPORTANT FACTOR (O.H. #2).

(b) Aspect

-discuss exposure to wind, difference between windward and lee slopes. STRESS WIND AS CRITICAL FACTOR (Slide #4 and 5)
-discuss exposure to sun, difference between sun exposed and shaded slopes in winter (Slide #6 and 7); in spring (Slide #8 and 9).

(c) Elevation

Discuss difference in snow depth, effect of wind and sun between valley bottom and mountain top (Slide #10 and 11).

(d) Configuration

-describe the influence of size and shape (Slide #12, 13 and 14)
-describe the influence of convex and concave slopes (O.H. #3) (Slide #15 & 16).

(e) Vegetation and Ground Features

-discuss effect of ground features (O.H. #4) (Slide #17 and 18)
-discuss effect of vegetation; thick timber; thin timber; where slides will start; few shrubs that act as stress concentrations; and fracture line (Slide #19, 20 and 21).

(f) Review

Show slides of starting zones, involving class in discussion of key factors for each slide (Slide #22 - 26).

5.5.4 Track and Runout Zones

-discuss effect on motion of open versus channelled track (Slide #27 - 30)
-discuss effects of rock, natural diversions (Slide #31, 32 and 33)
-vegetation indicators and runout zone (Slide #34, 35, and 36)
-extent of runout depends on incline, type and speed of avalanche (Slide #37, 38 and 39).

5.5.5 Terrain Traps

-discuss terrain traps, such as gullies, creek bottoms, cliff bands, cirques, and show example(s) of avalanche accidents that occured in terrain traps (eg. Yoho Valley, Feb. 1981) (Slide #40 - 50)
-small slopes are hazardous, but are often dismissed as inconsequential. Stress recognition and avoidance of these "small slopes" traps.

5.5.6 Decision Making/Route Finding

The only way to guarantee avoiding avalanche accidents is to stay off of all avalanche terrain. TO DO THIS YOU MUST BE ABLE TO RECOGNIZE AVALANCHE TERRAIN.

A) AVALANCHE SLOPE OR THREATENED BY AVALANCHE SLOPE? OR OTHER OBVIOUS HAZARDS

YES — NO

NO: GO SKIING

B) IS THE SLOPE ABSOLUTELY SAFE?

NO — YES

YES: (avalanche is down, slope totally cleaned out) GO SKIING

C) CAN THIS SLOPE BE AVOIDED?

NO — YES

YES: SKI AROUND THE SLOPE

D) ARE THE CONSEQUENCES OF AVALANCHE RELEASE ACCEPTABLE?

NO — YES

YES: (very small path, snowpack "stable", runout safe)

NO: CHOOSE ANOTHER ROUTE, CHOOSE ANOTHER OBJECTIVE OR GO HOME

YES: SKI ONE AT A TIME, OTHERS BE PREPARED TO HELP AND WATCH FROM A SAFE LOCATION

5.6 SUMMARY

Wrap up using key words.

5.7 LINK

This afternoon, the class will be in the field evaluating avalanche terrain.

CHAPTER VI

SAFETY AND SURVIVAL

CHAPTER VI

SAFETY AND SURVIVAL

6.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- slide projector
- carousel and slides
- flip chart, paper and pens

A selection of
- transceivers (different brands on 2.275 kHz.)
- shovels
- probes
- first aid kit(s)
- avalanche cord, etc.

C. Suggested time - 1 1/4 hours

6.1 AIM

Knowledge of best equipment and techniques available to increase survival chances of self and companions.

6.2 OBJECTIVES

At the end of this session the participant should be able to:

1. List equipment required for travel in avalanche terrain
2. Describe transceiver search techniques
3. Describe safe travel techniques
4. List actions if caught in an avalanche
5. List actions if buried in an avalanche
6. Describe pre-trip preparation and group organization techniques.

6.3 MOTIVATION

It is not always possible to avoid hazardous areas, therefore minimize the hazard through preparation and good leadership.

6.4 VALIDATION

1. Recount a case history of an avalanche accident where lack of adequate equipment and/or improper use resulted in loss of life (eg. Bourgeau Lake 1981).

2. Avalanche Handbook
   USDA - FS #489, pp. 186 - 202

3. Avalanche Safety for Skiers and Climbers
   Tony Daffern
   Chapter 1, pp. 17 - 22

6.5 EQUIPMENT

6.5.1 Transceivers

Demonstrate different types, advantages of each, and to wear secured inside clothing.

Describe transceiver search theory (bracketing) (O.H. #1).

** STRESS NEED FOR PRACTICE!

6.5.2 Shovels

Demonstrate different types, advantages of each; promote BIG SHOVELS.

6.5.3 Probes

Demonstrate different types of probes and probe poles, explain advantages of each.

6.5.4 First Aid Kit

Show a reasonable first aid kit, briefly describe contents.

6.5.5 Other Equipment

If available, demonstrate other safety/survival equipment on hand (cords, balloons, etc.)

6.5.6 Backup

Stress the habit of sign-in/sign-out with authorities or reliable friends.

6.6 TRAVEL IN AVALANCHE TERRAIN
(O.H. *2) (Table *3 for validation/motivation)

-transceiver and equipment check in a.m.
-avoid avalanche terrain where possible
-tighten clothing; loosen - wrist loops, safety straps, pack etc.
-place "spotter" top and bottom
-travel one at a time
-if area huge, spread out (50 m), stay in same track
-Traversing - prefer top of starting zone
- bottom of runout zone
- AVOID CROSSING MID-SLOPE
- choose an escape route
-skiing down - stay to the side; choose an escape route
-climbing up - in trees beside; up ridges (safe); hike straight up slope edge
-when across or down, stop close but safe to observe/ help partner.

NOTE: As a general rule, choose slopes with shortest slopes, shortest exposure time, most islands of safety.

Show slides of avalanche terrain, discuss terrain referring to lecture discuss safest routes (Slides *1, 2 and 3).

6.7 SURVIVAL CHANCES (O.H. *3)

Using latest statistics from NRC, show numbers of survivals, deaths, etc. from preceeding years.

6.8 SURVIVAL IN AVALANCHES (O.H. *4)

Stress the key to survival in avalanches is mental practice of correct responses to escape from the avalanche, or to prevent burial.

From your experience relate how proper response prevented serious accident.

**If you are caught in an avalanche:

-yell to alert companions
-look, determine size of slide
-go for best escape route
-if slab breaks up, jettison gear
-swim to stay on surface
-keep mouth shut, if turbulent
-body/head uphill, on back

**If buried:

-make air space with your hands
-push arm or leg to surface
-stay calm (oxygen comsumption)
-yell, if searchers nearby
-hope

6.9 SUMMARY

Review hazard recognition and avoidance.

Wrap up using key words.

6.10 LINK

Class will travel to trip site and, this afternoon, practice transceiver search and safe travel practices while we observe and evaluate avalanche terrain.

TABLE 3

SOME ROCKY MOUNTAIN AVALANCHE ACCIDENTS

1.	11 July 1955	Mt. Temple	7 climbers killed
2.	11 Mar. 1956	Marmot Basin	1 skier killed
3.	17 Mar. 1957	Richardson Ridge	1 skier killed
4.	23 Nov. 1958	Bow Summit	2 skiers killed
5.	30 Dec. 1962	Mt. Whaleback	1 skier killed
6.	28 Feb. 1965	Mt. Norquay	1 skier killed
7.	30 Jan. 1967	Mt. Whitehorn	1 skier killed
8.	9 Dec. 1967	Parker Ridge	1 skier killed
9.	23 Mar. 1969	Mt. Hector	1 skier killed
10.	24 Jan. 1970	Westcastle	1 skier killed
11.	24 Dec. 1971	Flathead Valley	3 people on road killed
12.	19 Feb. 1972	Mt. Edith Cavell	3 climbers killed
13.	9 Dec. 1973	Bow Summit	1 skier killed
14.	30 Mar. 1974	Sunshine Area	1 skier killed
15.	12 Dec. 1976	Chancellor Peak	3 climbers killed
16.	15 Feb. 1977	Parker Ridge	1 skier killed
17.	16 Mar. 1977	Diana Lake	1 skier killed
18.	19 Mar. 1977	Bow Peak	1 climber killed
19.	27 Mar. 1977	Quartz Ridge	1 skier killed
20.	30 Mar. 1977	Lake Louise	1 skier killed
21.	9 Oct. 1977	Mt. President	1 climber killed
22.	24 Feb. 1979	Stanley Glacier	2 skiers killed
23.	28 Feb. 1979	Tangle Hill	1 climber killed
24.	22 Feb. 1981	Yoho Valley	1 skier killed

25.	23 Feb. 1981	Bourgeau Lake	1 skier killed
26.	23 Feb. 1981	Mt. Thompson	2 skiers killed
27.	2 Apr. 1981	Mt. Stephen	2 climbers killed
28.	5 Feb. 1982	Cirrus Mountain	1 climber killed
29.	22 Feb. 1982	Marmot Peak	1 skier killed
30.	16 Aug. 1982	Mt. Kitchener	1 climber killed
31.	25 Aug. 1982	Mt. Robson	2 climbers killed
32.	Nov. 1982	Mt. Lefroy	1 climber killed
33.	2 July 1983	Mt. Bowlen	1 climber killed

CHAPTER VII

PM - DAY 2 FIELD TRIP

CHAPTER VII

PM - DAY 2 FIELD TRIP

7.0 INSTRUCTOR'S NOTES

A. Location - mountainous avalanche terrain with easy access

B. Instructional aids - full travel gear
- transceiver
- shovel
- probe
- first aid kit
- inclinometer
- compass

C. Suggested time - 4 hours

7.1 AIM

Demonstration and practice of safety and survival measures. Practical application of lecture material.

Practice evaluation of avalanche terrain under supervision.

7.2 OBJECTIVES

At the end of this session the participant will be able to:

1. Demonstrate transceiver search technique and find buried transceiver(s)
2. Check transceivers for function and signal strength
3. Describe terrain features
4. Explain principles of safe route finding
5. State safety precautions for travel in avalanche terrain.

7.3 MOTIVATION

Proper evaluation of terrain and consistant application of safety precautions provide a "margin of safety". Good leadership in the mountains is based on minimizing risk.

7.4 VALIDATION

1. Refer to current NRC statistics of survivors, burials, etc.

2. Refer to live recovery of avalanche victim

wearing transceiver (eg. Whistler Mtn. 1978).

3. Short personal anecdote where application of safety precautions prevented tragedy.

7.5 TRANSCEIVER PRACTICE

-demonstrate proper technique, then have students find a buried transceiver
-demonstrate proper technique for daily transceiver transmit/receive check
-use 20 m grid distance.

7.6 TERRAIN EVALUATION

Travel to nearest suitable avalanche terrain, discuss and evaluate terrain, using key headings used in terrain lecture.

- starting zones
- track
- runout zone
- incline
- aspect
- elevation
- configuration
- vegetation
- track and runout characteristics

7.7 SAFETY MEASURES

Ensuring an adequate margin of safety, travel through/around avalanche terrain, demonstrate how things should be done, and your reasons for your actions. Encourage group discussion.

NOTE: Demonstrate exemplary leadership. Make sure everyone understands how and what they are to do.

Ensure your field demonstrations reinforce, not contradict, the preceeding lecture material.

7.8 SUMMARY

Recap of how and why things were done.

7.9 LINK

These safety measures must be practiced on all future field trips. They should eventually become automatic, second nature.

CHAPTER VIII

STABILITY EVALUATION

CHAPTER VIII

STABILITY EVALUATION

8.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- slide projector
- carousel and slides
- flip chart, pens and paper

C. Suggested time - 1 1/2 hours

8.1 AIM

Understanding of how terrain, snowpack structure and weather parameters combine to determine snowpack stability.

8.2 OBJECTIVES

At the end of this session the participant should be able to:

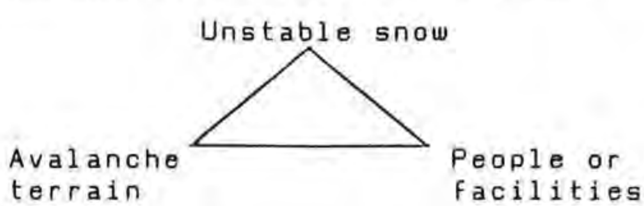
1. State threshold depths for slab avalanches
2. Describe three types of slab formation
3. Describe two mechanisms for slab failure
4. State eight criteria for evaluating snowpack stability
5. Describe stability changes resulting from changes in snowpack structure or weather.

8.3 MOTIVATION

Many complex and poorly understood factors combine in infinite combinations to affect snowpack stability. However, general rules have evolved that assist in decision making. This lecture outlines these rules to assist group leaders in making valid safety decisions.

8.4 VALIDATION (O.H. #1)

1. The Avalanche Accident Triangle



If you must travel through avalanche terrain, ability to evaluate snowpack stability is essential for accident prevention.

2. Avalanche Handbook
   USDA - FS
   Chapter 5, pp. 94 - 108

3. These are the primary factors considered by professional avalanche forecasters.

8.5 THRESHOLD DEPTH (O.H. #2) (Link-terrain)

For avalanche formation, normal minimum depths of snow are, for:

(a) smooth ground - 30 cm
(b) average mountainside - 60 cm
(c) very rough, big boulders, logs, etc. 90 - 120 cm

THIS IS KNOWN AS THRESHOLD DEPTH. Review the concept of ground anchors.

8.6 STRATIFICATION (O.H. #3)

Required for slab avlanches. Link snow terrain, wind and weather.

RELATIVELY STRONG X TENSION = SLAB AVALANCHE
RELATIVELY WEAK

*Stress difference between relative and absolute strength for slab formation.

(a) IN NEW, DRY SNOW, slab equation may be caused by:

- temperature rise during storm (density increase)
- increased winds (smaller grain sizes = denser snow)
- increased humidity (raining etc.)
- sun effects (sun, no sun, differences in stability due to radiation, at different times of the year).

(b) IN OLD, DRY SNOW, slab equation may be caused by:

- faceting or depth hoar at base of snowpack
- poorly sintered old snow overloaded by new snow
- poorly bonded layers

*Stress the main factors in determining layer strength:

1. density
2. grain size
3. sintering
4. temperature - warm = weak 0° to -2°
   - moderate = strong -2°
   - very cold = brittle -10° and colder

(c) IN WET SNOW, slab equation may be caused by:

- heavy wet, saturated layer, over wet lubricated layer of older snow.

8.7 SLAB FAILURE MECHANISMS REVIEW

8.7.1 SLOW SLOPE LOADING (eg. gentle snowfall - input energy dissipated by ET processes, settlement and creep. However, elastic strain may be raised to critical levels.

8.7.2 RAPID SLOPE LOADING - (eg. intense snowfall, cornice fall, ski pass, rain, explosion) energy dissipation cannot keep up with energy input; when force/strength equation exceeds catastrophic failure occurs. Result slab avalanche.

8.7.3 STRENGTH REDUCTION - faceting depth hoar formation weakening of layer resulting in loss of slab strength.

8.7.4 Fractures tend to propagate between stress concentrations (trees, rock, terrain breaks) that are normal "islands of safety" in popular myth. DISCUSS IMPLICATIONS FOR SKIER ROUTE FINDING. Note that TG formation is often accelerated at these "islands of safety" and that FRACTURES OFTEN INITIATE FROM THESE SUPPOSEDLY SAFE LOCATIONS (Slide #1, 2 and 3).

8.8 STABILITY EVALUATION CRITERIA

*Stress need for systematic approach. Stress variations over terrain and elevation.

8.8.1 Precipitation

Critical -storm snow depth greater than 20 cm
-precipitation intensity greater than 2 cm per hour (rapid loading)
-settlement of storm snow less than

15% per day
-specific gravity of new snow less than 0.05 or greater than 0.12

8.8.2 Snowpack Structure (Test profile)

Critical -weak layers and interfaces
-snow temperature 0°C or close to 0°C
-more than 30 cm deep snow on top of a weak layer
-loose, cold snow
-wet snow
-significant changes of hardness:
relatively strong
relatively weak
-rimed crystals, needles, graupels
-rain

8.8.3 Wind

A major factor in slab formation, considerable variation over terrain.

*Stress wind deposited snow is composed of broken particles therefore much denser (2X to 4X) than equal depth of undisturbed snow in the valley bottom.

Wind deposited snow is laid down on lee slopes and ON THE WINDWARD SIDES OF QUARTERING SLOPES.

(a) Winds of 0 - 15 mph are usually not significant.

(b) Winds of 15 - 50 mph produce significant transport of snow mass, amount dependent on wind patterns (gust transport more snow) and crystal shape and metamorphism (looseness), amount of snow available.

(c) Winds greater than 50 mph do not usually sublimate back into the atmosphere given low humidity.

8.8.4 Drifting Patterns (O.H. #4)

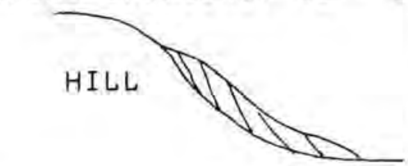
Low drifting, 15 - 25 mph

Usually high on slope

Moderate drifting, 25 - 40 mph

USUALLY mid slope, very dangerous as ski tests are made high on slope (usually) skiers well down onto slope before hazard is obvious

Extreme drifting, 40 - 50 mph



Mid to low slope, very dangerous (see above)

NOTE: The effect of wind is significant over a long period, therefore the speed and direction of wind must be considered for several previous days.

8.8.5 <u>Air Temperature</u>

-freezing levels
-consider the effects of the temperature on the snow strength and metamorphism
-critical - rapid changes of temperature
- temperature at freezing and above.

8.8.6 <u>Solar Radiation</u> (SUN)

-most significant in spring
-critical - sun on slopes under consideration
- sun with hazy sky.

8.8.7 <u>Avalanche Activity Observations</u>

*Critical - avalanches running on indicator slopes
- avalanches running on any slope
- no avalanches in the last storm.

8.8.8 <u>Physical Tests</u>

-shovel shear test
-foot penetration 30 cm
-test skiing
-settlement felt while on or near slope
-cracks propagating from tracks
-other tests.

8.8.9 Weather Forecast

-storm warnings
-approaching warm fronts
-high winds
-precipitation forecasts.

8.9 SUMMARY

HAZARD EVALUATION:

1. Terrain - exposure
2. Snow stability - avalanches
   - type
   - trigger
3. Weather - changes
   - hazard forecast

Re-emphasize that all factors must be evaluated in combination with other factors. Inter relationships of factors are poorly understood. Stress need for margin of safety to compensate for knowledge gaps.

Use case history examples to combine factors.

8.10 LINK

This afternoon we will practice stability evaluation during the field trip.

CHAPTER IX

FIELD TRIP DAY 3

CHAPTER IX

FIELD TRIP DAY 3

9.0 INSTRUCTOR'S NOTES

A. Location - mountainous avalanche terrain with easy road access - short travel time from classroom

B. Instructional aids - complete winter travel and survival equipment
- complete snow study kit

C. Suggested time - 8 hours

9.1 AIM

Instructor demonstration and student practice of stability evaluation, field testing procedures and analysis.

Instructor demonstration and student practice of route selection and safety measures procedures.

Student practice of hazard analysis and forecasting under instructor supervision.

9.2 OBJECTIVES

At the end of this session the participant should be able to:

1. Demonstrate field procedure for evaluating snowpack stability
2. Justify route finding choices
3. State required safety procedures for the terrain selected
4. Determine the degree of hazard encountered
5. Forecast hazard for a selected route.

9.3 MOTIVATION

Student practice of these skills is required to develop a "frame of reference", against which future situations can be judged.

9.4 VALIDATION

Good decision making is based on experience. This field trip will give basic experience, with supervision to correct any judgement errors.

9.5 FIELD TRIP

9.5.1 Do travel equipment check

9.5.2 Test transceivers for receive/transmit

9.5.3 Travel to test profile site, demonstrate group control techniques

9.5.4 Do test profile
- discuss weather influences
- block test
- pie test
- Swiss wedge
- compressive test (for TG snowpack)

9.5.5 Determine and discuss stability evaluation

9.5.6 Evaluate terrain

9.5.7 Determine reasonable objective

9.5.8 Practice route selection

9.5.9 Forecast hazard for route on different aspect and higher/lower elevation

9.5.10 Travel to objective

9.5.11 Test for snowpack stability (test profile)

9.5.12 Discuss reasons for differences in test profile

9.5.13 Practice safety measures on return route to vehicles

9.5.14 Practice group control on return route to vehicles.

9.6 SUMMARY

Assemble group, summarize conditions encountered and rationale for decisions made and safety measures employed.

9.7 LINK

Tomorrow students will be in a different area, and will act as leaders to demonstrate their competance in skills learned today.

CHAPTER X

SEARCH AND RESCUE

CHAPTER X

SEARCH AND RESCUE

10.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - overhead projector
- O.H. transparencies
- slide projector
- carousel and slides
- flip chart and paper, pens
- case histories

C. Suggested time - 2 hours

10.1 AIM

Knowledge of proper response and leadership required to find and rescue avalanche victims.

10.2 OBJECTIVES

At the end of this session the particpant should be able to:

1. Conduct avalanche rescue operations
2. Describe avalanche search procedures
3. List safety procedures for rescuers
4. Determine likely burial locations for persons(s) caught in avalanches
5. List local organized rescue services.

10.3 MOTIVATION

Backcountry travellers must be capable of competently finding and rescuing a buried companion if an avalanche accident occurs.

10.4 VALIDATION

1. Survival rate of buried persons who are recovered by companions vs recovered by organized resuce teams.
   Avalanches - Protection, Location, Rescue
   Varnni Eigenman Foundation

2. Current N.R.C. avalanche involvement statistics.

10.5 REVIEW

10.5.1 Review Avalanche Dynamics

Review avalanche dynamics and deposition patterns stressing implications to victim and most likely burial location (Slides #1 - 8).

10.5.2 Review Survival Techniques

Review survival techniques, self rescue actions that a person caught in an avalanche should do to aid survival (Slides #9 - 12).

10.5.3 Review Rescue Equipment (O.H. #2)

Review equipment that should be carried by back country travellers in winter:

- rescue beacon
- probe
- shovel
- first aid kit

Review use of equipment.

10.6 SEARCH AND RESCUE LEADERSHIP

Discuss the importance of calm, rational and efficient leadership during rescue operations.

STRESS
- need for mental pre-planning and practice
- efficient use of time (relate to survival time) (O.H. #3)
- efficient use of resources
- need to prevent further burials
- need for strong, effective leadership and group cooperation
- discuss need for decisions based on assessment of problem and most effective solution.

10.7 AVALANCHE SEARCH PROCEDURES

If your companion is caught in an avalanche:

- observe closely, note victims location when release occurs
- watch victim from start to finish
- if victim disappears, note that spot, follow that mass of snow until it stops
- when avalanche stops, carefully note victim's probable burial location
- DO NOT PANIC
- establish firm, decisive leadership immediately

- assess remaining avalanche hazard
- do not lose others in your rescue attempt
- post avalanche guard if necessary and possible
- mark "caught" and "last seen point" locations if possible
- determine likely burial area
- proceed to that area safely and quickly
- if necessary, designate and prepare escape route.

10.7.1 If Victim is Wearing a Transceiver

- do a thorough surface and beacon search simultaneously
- beacon search patterns (O.H. #4, 5 and 6)
- mark and note location of all articles found
- when signal heard, "bracket" to locate victim (O.H. #7)
- do final location of victim with probe
- evacuate as quickly as possible
- give first aid if required.

10.7.2 If Victim is Not Wearing a Transceiver

- do a thorough surface search, mark and note location of articles found
- random probe while doing surface search
- if group of survivors is large (8 or more) the prospect of success poor, and help is one hour or less away, send two for help
- if group of survivors is small, or help is far away, all survivors search until hope is passed
- if surface search unsuccessful, set up coarse probe line in most likely burial area (O.H. #8, 9 and 10)
- probe entire possible burial area, mark all areas probed
- if unsuccessful, repeat until victim is found
- when victim is located, quickly dig down along probe to victim
- give first aid as appropriate
- arrange transportation as required
- avoid avalanche terrain on the way home.

10.8 AVALANCHE VICTIM RESCUE

10.8.1 If You Require Organized Services

The following information is required:

- exact location
- is terrain flat or steep, open or trees? (helicopter access)
- present weather in the area
- number of persons buried

-time of accident
-number and condition of survivors
-nearest trailhead or access
-your name and location
-brief description of accident.

10.8.2 REPORT RESCUE CALLS TO - prepare for each individual area a call list (O.H. #11).

Prepare a resource list for your area.

10.9 CASE HISTORIES

Use remaining time to use local case histories to demonstrate good and bad accident responses. (Do not be vindictive, unkind or use names when portraying case histories).

10.10 SUMMARY

Wrap up using key words.

STRESS NEED FOR MENTAL PREPARATION AND GOOD LEADERSHIP.

10.11 LINK

Tomorrow group will practice avalanche rescue in a simulation.

One of the class will have to act as leader (MENTAL PREPARATION).

CHAPTER XI

DAY 4 FIELD TRIP

CHAPTER XI

DAY 4 FIELD TRIP

11.0 INSTRUCTOR'S NOTES

A. Location - mountainous avalanche terrain, with good access. Preferably not same site as for Day 3 field trip.

B. Instructional aids - full mountain travel and survival gear
- complete snow study kit
- complete safety gear

C. Suggested time - 8 hours (arrive and leave in daylight)

11.1 AIM

Practice group leadership using knowledge and techniques learned during the course, under instructors supervision.

Practice avalanche rescue stressing leadership development.

11.2 OBJECTIVES

At the end of this session the participant will be able to:

1. Evaluate hazard for route selected
2. Demonstrate acceptable group leadership
3. Lead a simulated rescue.

11.3 MOTIVATION

This experience provides a frame of reference from which to evaluate future situations.

11.4 VALIDATION

From your experience relate:

a) Where good leadership/decision resulted in a demonstrated safe action

b) Where bad leadership/decisions resulted in unsafe situations.

11.5 FIELD TRIP

11.5.1 Leadership Development

- -choose an objective suitable for a morning climb up, have students "lead" trip
- -have students analyze terrain, snowpack, efficient travel routes, weather influences, that effect stability evaluation
- -have students make decisions on safe travel routes and safety measures required, forecast upcoming conditions along route
- -have students demonstrate and practice good group control procedures
- -instructor to act as quality control during above, to ensure a positive learning situation

11.5.2 Avalanche Rescue

- -out of sight of class, instructors prepare avalanche accident simulation
- -bury coveralls without transceiver and coveralls with transceiver to be "found" during rescue practice
- -appoint a student as "leader"
- -have group do "rescue" without interruption from instructor(s)
- -assemble group, CONSTRUCTIVELY critique rescue simulation
- -repeat simulation of rescue under instructors leadership, demonstrate ideal performance as group leader for students "frame of reference"
- -assemble gear and travel in organized manner to trailhead.

11.6 SUMMARY

Wrap up of day, with objective of providing understanding of or corrections to, events of the day.

11.7 LINK

The course is finishing, students will now be on their own to use the knowledge and skills learned on the course. The experience of this and preceeding days for experience of a safe "frame of reference".

CHAPTER XII

EVENING DAY 4

CHAPTER XII

EVENING DAY 4

12.0 INSTRUCTOR'S NOTES

A. Location - classroom

B. Instructional aids - O.H. projector
- O.H. transparencies
- slide projector
- slides and carousel
- flip chart, pens and paper
- beer

C. Suggested time - 2 hours

12.1 AIM

Tie course together, clear up any misconceptions, conclude course on enthusiastic, positive note.

12.2 OBJECTIVES

By the end of this session the participant should be able to:

1. Demonstrate good group leadership
2. Describe avalanche search and rescue techniques
3. List key elements of the course and relate these elements to field situations
4. Critique the course instructors and content to promote improvements.

12.3 MOTIVATION

From now on students will be on their own, without supervision of more knowledgeable persons.

12.4 VALIDATION

N/A

12.5 CONTENT

Recap day, group discussion of leadership, group critique of rescue practice.

Questions and answers, re: any student questions on preceeding course content or related subjects.

Instructor to stress need for understanding and respect for avalanches, not irrational fear (you miss alot of good skiing).

Instructor to stress need for avoidance of avalanche terrain whenever possible.

Instructor to stress need for margin of safety to compensate for knowledge gaps.

Instructor to stress need for thorough and thoughtful analysis of hazards in the mountains.

Have students evaluate course and instructors to provide feedback on how course has met their needs, and how course could be improved.

12.6 SUMMARY

As appropriate, wrap up of course.